MAY 1 3 1947

Volume 37 *Number 4*

Science Library

Phytopathology

AN INTERNATIONAL JOURNAL

April 1947

Official Organ of

The American Phytopathological Society

$6.25 per year, Canada $6.00 per year, United States and dependencies $6.50 per year, elsewhere

Office of Publication

Corner North Queen Street and McGovern Avenue, Lancaster, Pennsylvania

Entered at the postoffice in Lancaster, Pennsylvania, as second-class matter. Acceptance for mailing at the special rate of postage provided for in paragraph 4, Sec. 538, P. L. and R. Authorized May 12, 1921.

TABLE OF CONTENTS

The isolation and behavior of bacteria-free crown-gall tissue from primary galls of Helianthus annuus ..... R. S. de Ropp 201

Ascochyta blight and leaf and pod spot of broad bean in China. T. F. Yu 207

Nutrition of the trees and development of Dutch elm disease. K. G. Parker, L. J. Tyler, D. S. Welch, and Seth Pope 215

Bacterial lenticel infection of early potatoes. M. A. Smith and G. B. Ramsey 225

Tubercularia canker and dieback of Siberian elm (Ulmus pumila L.). J. C. Carter 243

The mode of vector feeding and the tissues involved in the transmission of Pierce's disease virus in grape and alfalfa. Byron R. Houston, Katherine Esau, and Wm. B. Hewitt 247

Book reviews 254

Report of the 38th annual meeting of The American Phytopathological Society. 255

Revised constitution of The American Phytopathological Society 265

PHYTOPATHOLOGY

An International Journal
Official Organ of The American Phytopathological Society

EDITORS

HELEN HART, Editor-in-Chief, University Farm, St. Paul 1, Minnesota.
W. H. BURKHOLDER, Cornell University, Ithaca, New York.
A. J. RIKER, University of Wisconsin, Madison 6, Wisconsin.
H. A. RODENHISER, United States Horticultural Station, Beltsville, Maryland.

ASSOCIATE EDITORS

E. J. ANDERSON, Pineapple Research Institute, University of Hawaii, Honolulu, Hawaii.
G. M. ARMSTRONG, Clemson Agricultural College, Clemson, South Carolina.
L. M. BLACK, Brooklyn Botanic Garden, Brooklyn 25, New York.
DONALD E. BLISS, Citrus Experiment Station, Riverside, California.
H. LORAN BLOOD, Utah Agricultural Experiment Station, Logan, Utah.
F. L. DRAYTON, Central Experimental Farm, Ottawa, Canada.
A. L. HARRISON, Arizona Agricultural Experiment Station, Tempe, Arizona.
RAY R. HIRT, New York State College of Forestry, Syracuse 10, New York.
BYRON R. HOUSTON, University of California, Davis, California.
F. L. HOWARD, Rhode Island State College, Kingston, Rhode Island.
M. F. KERNKAMP, University Farm, St. Paul 1, Minnesota.
C. M. TUCKER, University of Missouri, Columbia, Missouri.

BUSINESS MANAGEMENT

M. C. RICHARDS, Business Manager, University of New Hampshire, Durham, New Hampshire.
L. J. ALEXANDER, Advertising Manager, Ohio Agricultural Experiment Station, Wooster, Ohio.

NOTICES

All communications regarding subscriptions and back numbers should be sent to M. C. RICHARDS, Business Manager, University of New Hampshire, Durham, New Hampshire.

Subscription price. $6.00 per year United States and dependencies; Canada, $6.25; other countries $6.50; single numbers of the current volume, 60 cents each. The Journal has been issued monthly beginning with Volume 8, January, 1918. Prior to that it was issued bimonthly.

Separate Numbers may be purchased from broken volumes, and stocks available are as follows: Vol. 1, No. 1, index; Vol. 2, Nos. 1, 5, index; Vol. 3, No. 5; Vol. 6, index; Vol. 8, Nos. 2, 3, 5, 6, 7, and 9 through 12; Vol. 9, Nos. 2 through 12, index; Vol. 10, Nos. 2 through 12. Separate numbers of volumes 1 through 10 are sold at $2.00 per copy, those of volumes 11 through 36 at $1.25 a copy. Complete, unbound volumes 11 through 36 are available at $10.00 a volume.

Thirty-Year Index (to Vols. 1–30, 1911–1940) bound. $6.25, United States and Canada. $7.50, elsewhere.

Advertisements. Rates may be secured from the Advertising Manager. No indorsement of any statement of claims made in advertisement is assumed by this journal or by The American Phytopathological Society.

Lost Numbers. Claims for copies (domestic subscriptions) lost in the mails must be received within 30 days from the date of issue (Jan. 15 and monthly thereafter); otherwise the usual charge of 60¢ per copy will be made for replacements. Deliveries overseas are not guaranteed and foreign mailings are made at the subscriber's risk.

Separates. No gratis copies supplied. A printed schedule of prices is submitted with the proof, and authors may secure separates by placing an order on the blanks provided when proof is returned.

Manuscript may be sent to the nearest member of the editorial board. Clearness, brevity, and conciseness are essential. In form and style, such as punctuation, spelling, and use of italic, manuscript should conform to the best usage in recent numbers of this journal. Manuscripts should be typed on one side of the paper, double spaced, and sent unfolded. Papers longer than four printed pages should include a summary. The name and address of the institution at which the work was done should be included at the end of the summary. Footnotes should be numbered consecutively with arabic numerals except in tables, where small letters should be used. Each table should have a heading stating clearly and concisely its contents. References to literature should be made as footnotes only when five or fewer citations are given. The simplified method of citing literature used in recent numbers of this journal should be followed. References in "Literature Cited" should be listed aphabetically and numbered consecutively. Authors are advised to read "The preparation of manuscripts for Phytopathology" by A. J. Riker, published in Phytopath. 36: 953–977. 1946.

Illustrations necessarily must be limited in number. Photographs, to reproduce satisfactorily, must be of best quality. Authors who desire unusual numbers of illustrations or special types of illustrations will be asked to bear part of the cost, i.e. in excess of $12.50, the approximate cost of 2 full-page cuts. All illustrations are reproduced on the same grade of paper and will be run as text figures designated by arabic numerals. Individual illustrations within a text figure should be designated by letters. Full-page figures should be arranged to conform to journal page size and shape ($4\frac{1}{2} \times 7$ inches) after making due allowance for reductions. Specific reference to each illustration must be made in the text. Each illustration must be accompanied by an adequate legend, the legend to be typed on separate paper and not on the illustration.

The responsibility for statements, whether of fact or opinion, rests entirely with the writers thereof.

The American Phytopathological Society

FOUNDED 1909. INCORPORATED 1915

The A. P. S. Council for 1947

President—A. J. Riker, University of Wisconsin, Madison 6, Wisconsin.
Vice-President—R. S. Kirby, Pennsylvania State College, State College, Pennsylvania.
Secretary—E. M. Johnson, Agricultural Experiment Station, Lexington 29, Kentucky.
Treasurer—M. C. Richards, University of New Hampshire, Durham, New Hampshire.
Editor-in-Chief—Helen Hart, University Farm, St. Paul 1, Minnesota.

Councilors:

E. E. Clayton, Bureau of Plant Industry, Beltsville, Maryland.
S. G. Lehman, N. C. State College, Raleigh, North Carolina.
Thomas Sproston, Jr., University of Vermont, Burlington, Vermont.
James H. Jensen, North Carolina State College, Raleigh, North Carolina.
Max W. Gardner, University of California, Berkeley, California.
C. M. Tucker, University of Missouri, Columbia, Missouri.
J. H. Craigie, Central Experimental Farm, Ottawa, Canada.

Sustaining Associates:

B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio.
Mallinckrodt Chemical Works, Second and Mallinckrodt Street, St. Louis 7, Missouri.
Givaudan-Delawanna, Inc., 330 West 42nd Street, New York 18, New York.
Rohm and Haas, Washington Square, Philadelphia 5, Pennsylvania.
E. I. du Pont de Nemours & Company, Wilmington 98, Delaware.
Freeport Sulphur Company, New Orleans 5, Louisiana.
Tennessee Corporation, 619–27 Grant Building, Atlanta 1, Georgia.
Flax Institute of the United States, Roanoke Building, Minneapolis, Minnesota.
Pillsbury Mills, Inc., Metropolitan Building, Minneapolis, Minnesota.
Rogers Bros. Seed Co., Inc., Idaho Falls, Idaho.
F. H. Woodruff and Sons, Milford, Connecticut.
Minnesota Valley Canning Co., Le Sueur, Minnesota.
Triarch Botanical Products, Ripon, Wisconsin.
Yoder Brothers, Inc., Barberton, Ohio.
Butler County Mushroom Farm, Inc., West Winfield, Pennsylvania.
Pabst Brewing Company, Milwaukee, Wisconsin.
Associated Seed Growers, Inc., New Haven 2, Connecticut.
Ferry-Morse Seed Co., Detroit, Michigan.
The Dow Chemical Company, Midland, Michigan.
Lederle Laboratories Division, American Cyanamid Company, Pearl River, N. Y.

THE ISOLATION AND BEHAVIOR OF BACTERIA-FREE CROWN-GALL TISSUE FROM PRIMARY GALLS OF HELIANTHUS ANNUUS

R. S. DE ROPP[1]

(Accepted for publication December 9, 1946)

That bacteria are frequently absent from secondary crown-gall tumors of sunflower was demonstrated clearly by Braun and White (2). The same phenomenon was observed earlier by Smith, Brown, and McCulloch (7), who recorded several instances in which they were unable to isolate *Phytomonas tumefaciens* from secondary galls on Paris daisy. These workers, however, attributed their failure to faulty technique or to the cultural peculiarities of the parasite. Significant observations were also made by Jensen (3), who studied the naturally occurring galls on beets. Such galls were almost unquestionably caused by *Phytomonas tumefaciens* and showed, when grafted into healthy plants, the same capacity to produce tumors as was later demonstrated by White and Braun (9), using bacteria-free crown-gall tissues from secondary galls of sunflower. Jensen concluded "The tumours in beets are undoubtedly caused by *Bacterium tumefaciens*, but in older tumours, the bacteria die off, and careful investigation of a large number of spontaneous tumours from mangels and sugar beets, taken up in autumn, led only in a single instance to isolation of the bacterium." The work to be described in this paper was linked with these findings of Jensen. It was designed to ascertain whether primary galls on sunflower, tobacco, and tomato ever became free of bacteria, thus forming a source of bacteria-free tumor tissue such as was isolated from secondary galls on sunflower (9) or from galls on heat-treated periwinkle plants (1, 8).

EXPERIMENTAL WORK

Plants of sunflower (*Helianthus annuus* L.), tomato (*Lycopersicon esculentum* Mill.), and tobacco (*Nicotiana tabacum* L.) were inoculated at 4 to 6 weeks of age with a 48-hour broth culture of *Phytomonas tumefaciens*, strain A6. The inoculation was made by means of a spear-headed needle dipped in the culture and inserted into one of the lower internodes of the plant. After 6 weeks' further growth, well-developed galls were produced at the site of inoculation. Internodes bearing these galls were rendered sterile by careful removal of the epidermis. The outer part of the gall was cut away by means of a sterile scalpel. The internode in the region of the gall was then cut into a series of sections about 3 mm. thick which were transferred to slopes of sucrose agar medium having the same composition as that employed by White and Braun (9) for the cultivation of secondary tumors.

[1] Research Officer, Agricultural Research Council, Great Britain, and Visiting Investigator, Department of Animal and Plant Pathology, The Rockefeller Institute for Medical Research, Princeton, New Jersey.

The behavior of these isolated fragments of tissue was closely observed during four weeks. From the fragments of tomato and tobacco tissue outgrowths of bacteria were observed after the cultures had been incubated from 3 to 4 days. The bacteria formed thick, mucilaginous films which covered the surface of the agar and proved, on inoculation into sunflower,

FIG. 1. *a*. Serial segments through a gall-bearing internode of sunflower after 6 days' culture *in vitro*. White masses of tumor tissue are visible in the fifth through the eighth segments. Bacteria are absent throughout. *b*. Same series of segments as in *a*, after 26 days' culture *in vitro*. Tumor tissue is more clearly visible, accompanied by the development of roots from normal tissue. *c*. Serial segments through a gall-bearing internode of sunflower after 6 days' culture *in vitro*. Bacteria were present in segments from above and below the gall and in one segment from the center of the gall, though absent from other segments. (× 0.45.) (Photographs by J. A. Carlile.)

to be *Phytomonas tumefaciens* in every instance. In both tomato and tobacco it appeared that the parasite had spread throughout the gall and extended for some distance into healthy tissue above and below it. None of

the stem cultures prepared from these plants proved to be free of the parasite.

When stem segments from infected sunflowers were cultured on nutrient agar in the same way a different result was obtained (Fig. 1, *a*). In 11 plants out of a group of 20 no bacteria could be isolated from any one of the series of stem segments. Even segments which had been excised from the center of the gall showed no signs of the organism. Segments from this region, however, frequently developed outgrowths of a white, friable tissue which grew rapidly, soon attaining a size greater than that of the original fragment. This white, disorganized tissue closely resembled, in appearance and mode of growth, the tumor tissue isolated by White and Braun (9) from secondary galls on sunflower. The masses of tumor tissue can be seen growing out of the stem fragments in figure 1, *b*. From the normal tissue of such fragments a copious outgrowth of roots generally took place. Sections of these segments indicated that the roots arose in normal tissue probably under the stimulus of a root-forming substance generated by the tumor tissue (See Fig. 2, *b*).

In 9 out of the 20 sunflower plants examined bacteria were isolated from some or all of the stem segments. The distribution of bacteria amongst these segments was often irregular (See Fig. 1, *c*), the organisms being frequently present in the stem above and below the gall though absent from the gall region itself. It must be emphasized, however, that the entire gall was not cultured in these cases, since, in order to obtain sterile tissue, the external surface of the gall had to be removed. It has been stated by Robinson and Walkden (4) that *Phytomonas tumefaciens* multiplies on the external surface of galls; and Braun and White (2), who tested one hundred primary galls from sunflowers, recovered bacteria from all of them. These results, therefore, only indicate that the interior of the gall on sunflower is often free of bacteria though it may and usually does contain altered tissue capable of autonomous growth.

Those segments of sunflower stem which contained tumor tissue but were free from bacteria were transferred to fresh agar in 250-ml. flasks after a period of one month. The tumor tissue continued to proliferate rapidly, giving rise to large tissue masses containing both normal and tumor tissue held in the agar by a considerable growth of roots (Fig. 2, *a*). After a further month of culture these masses were removed from the flasks and the tumor tissue was separated from the normal tissue as far as possible; fragments of it were then transferred to agar slopes. From fragments of three different sunflower plants three new strains of bacteria-free tumor tissue were isolated. These were designated P_I, P_{II}, and P_{III}. The behavior of these fragments in culture was fundamentally different. P_I and P_{III} both grew freely on the surface of the agar as whitish, friable masses tending to become brown with age. Strain P_I at first tended to produce roots (Fig. 2, *c*), though this tendency later disappeared and may only have been due to contamination of the tumor tissue with normal tissue. Strain P_{II}, however,

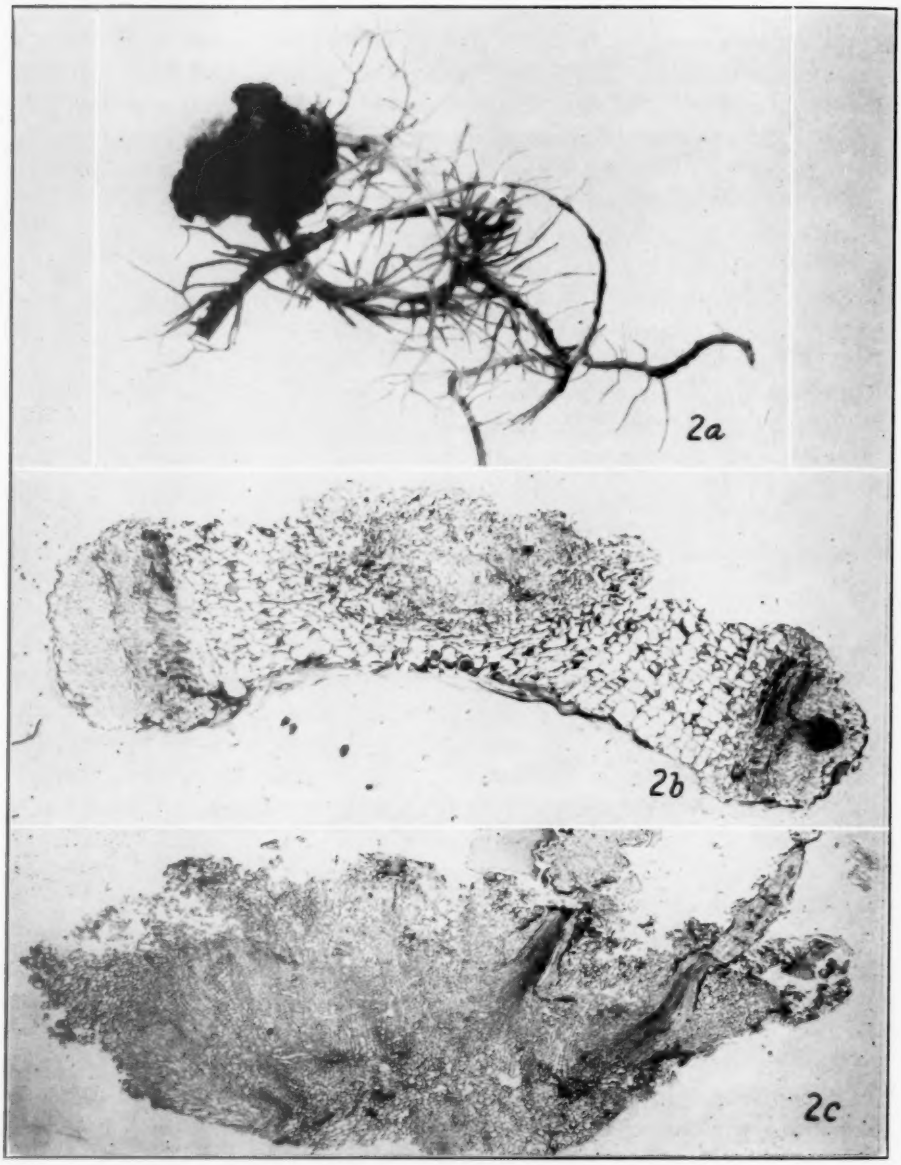

FIG. 2. *a*. Mixed normal and tumor tissue with roots cultured from a bacteria-free segment of primary gall on sunflower. *b*. Longitudinal section of the segment from gall-bearing internode of sunflower showing production of root initial in normal tissue probably resulting from stimulus by central mass of tumor tissue. *c*. Root production in an early subculture of strain P_1 derived from a primary sunflower tumor. (×1.2; ×14.8; ×9.3.) (Photographs by J. A. Carlile.)

tended to grow down into the medium and the consistency of the tissue produced by the strain was firm and woody. The difference in structure of the soft as compared with the woody strain can be seen in figure 3, *a* and *b*. All these strains of tissue, when grafted into intact sunflower plants by the method described by White and Braun (9), proved capable of autonomous growth, giving rise to large tumors on the stems of the host plants.

SUMMARY AND CONCLUSIONS

Tissue isolated from crown galls on tobacco and tomato was always found to contain viable organisms of *Phytomonas tumefaciens* in large numbers. The interior tissues of primary galls on sunflower were frequently

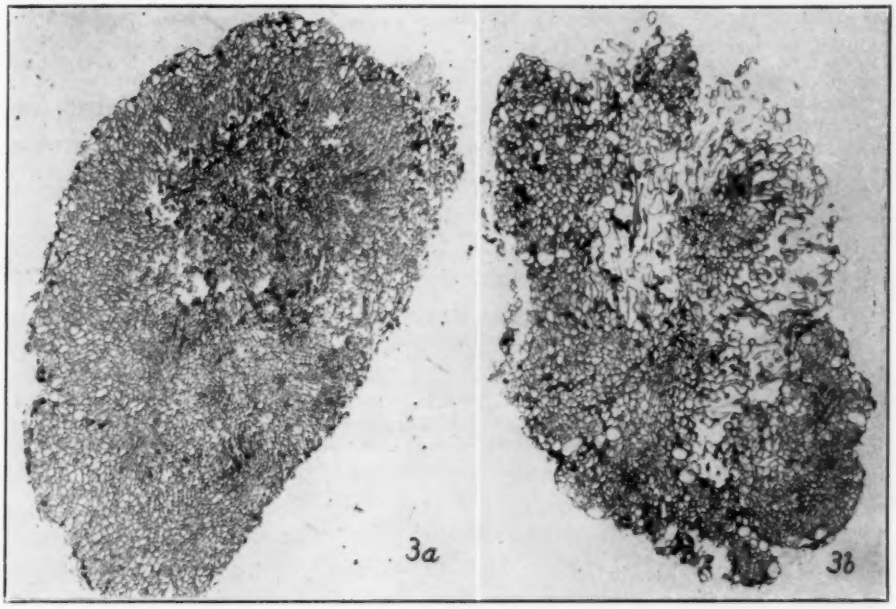

FIG. 3. *a*. Structure of the woody type of tumor tissue from strain P_{II} isolated from a primary tumor. *b*. Structure of the soft translucent tumor tissue from strain P_I isolated from a primary tumor. (×11.6.) (Photographs by J. A. Carlile.)

found to be free of bacteria and new strains of bacteria-free crown-gall tissue could be obtained from this source. Tumor tissue obtained in this way was generally mixed with normal tissue, and tended to throw out roots for some time after its original isolation. With more prolonged culture this tendency disappeared. The roots probably arose from fragments of normal tissue embedded in the tumor tissue and stimulated into activity by growth substances generated by the tumor tissue. It does not seem likely that roots could be generated out of tumor tissue itself as it has already been shown (5) that pure tumor tissue does not respond to root-forming hormones such as indole acetic acid. This inability of tumor tissue to differentiate into organs was also commented on by Smith (6), "The tumor cell is a disoriented degenerate

cell . . . and I know of no evidence going to show that it can develop subsequently into normal tissues, organs, or the whole plant; on the contrary, it tends steadily towards decay."

Two types of tumor tissue were isolated from the primary galls, a hard, woody type with a fairly well-defined internal structure, and a soft, translucent type. On prolonged culture the woody type of tissue tended to change into the soft, translucent type.

AGRICULTURAL RESEARCH COUNCIL, GREAT BRITAIN,
AND
THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH,
PRINCETON, NEW JERSEY.

LITERATURE CITED

1. BRAUN, ARMIN C. Studies on tumor inception in the crown-gall disease. Amer. Jour. Bot. **30**: 674–677. 1943.
2. ————, and P. R. WHITE. Bacteriological sterility of tissues derived from secondary crown-gall tumors. Phytopath. **33**: 85–100. 1943.
3. JENSEN, C. O. Investigations upon certain tumour-like formations in plants. Den K. Veterinaer- og Landbohøjskole, Aarsskrift. **1918**: 91–143. 1918.
4. ROBINSON, WILFRID, and H. WALKDEN. A critical study of crown gall. Ann. Bot. **37**: 299–324. 1923.
5. DE ROPP, R. S. The response of normal plant tissues and of crown-gall tumor tissues to synthetic growth hormones. Amer. Jour. Bot. **34**: 53–62. 1947.
6. SMITH, ERWIN F. Effect of crowngall inoculations on Bryophyllum. Jour. Agr. Res. [U.S.] **21**: 593–598. 1921.
7. ————, NELLIE A. BROWN, and LUCIA MCCULLOCH. The structure and development of crown gall: a plant cancer. U. S. Dept. Agr., Bur. Plant Indus. Bull. **255**. 1912.
8. WHITE, PHILIP R. Metastatic (graft) tumors of bacteria-free crown-galls on *Vinca rosea*. Amer. Jour. Bot. **32**: 237–241. 1945.
9. ————, and ARMIN C. BRAUN. A cancerous neoplasm of plants. Autonomous bacteria-free crown-gall tissue. Cancer Research **2**: 597–617. 1942.

ASCOCHYTA BLIGHT AND LEAF AND POD SPOT OF BROAD BEAN IN CHINA

T. F. Yu[1]

(Accepted for publication December 16, 1946)

INTRODUCTION

In the spring of 1926, when the writer began a study of the diseases of broad bean, *Vicia faba* L., in Nanking, China, special attention was given to the blight and leaf and pod spot of beans caused by *Ascochyta pisi* Lib. The disease is less prevalent than the red-spot disease caused by *Botrytis fabae* Sard. and Cercospora leaf spot caused by *Cercospora fabae* Fautr., as it, in general, is restricted to certain fields and bean-growing districts. It is, however, very destructive, because it blights bean plants and withers the pods.

DISTRIBUTION AND ECONOMIC IMPORTANCE

The disease has been found by the writer in Kiangsu, Chekiang, Anhwei, Kiangsi, Hupeh, Szechwan, and Yunnan provinces. To judge from the wide range of conditions under which the disease has already been found, there appears to be no reason to doubt that it will be found in practically all the important bean-growing regions in China.

Outside of China, the disease has been reported in Italy (1), Spain (2), England (8), United States (12), Germany (9), East Africa (6), Cyprus (7), and Japan (3).

Heavy losses were caused by the fungus to broad beans in many sections of Kiangsu in 1934. Diseased plants yielded less than one-half the normal crop. From 1934 to 1937, the disease appeared in many bean-growing regions along the Yangtze river. The losses were generally slight except in certain places where young plants had been blighted. In 1940, an epiphytotic was observed in the higher bean lands near Chenkiang, Yunnan. Affected plants were stunted and there was a general yellowing of foliage. Loss ranged from 80 to 100 per cent of the crop.

Losses from the disease are due to destruction of plants, low yield of affected plants, and to poor germination of affected seed. When the disease appears early in the spring, young growing plants may be severely attacked. In this case, pods wither before they mature. Sometimes, the blighting of certain shoots of a plant prevents pod set. Spotting of seed renders them unfit for use as a green vegetable.

REVIEW OF LITERATURE

The blight, and leaf and pod spot of broad bean, has been attributed to either *Ascochyta pisi* Lib. or *A. fabae* Speg. by various investigators. *Ascochyta pisi* was first described in 1830 by Libert (4) as the cause of blight of

[1] Formerly Professor of Plant Pathology, The University of Nanking, Nanking, China.

Pisum sativum L. In 1899, Spegazzini (11) described *Ascochyta fabae*, the cause of a dark yellow to brown leaf spot on *Vicia faba* L. from Argentina. This species of *Ascochyta* is characterized by large spores.

The *Ascochyta* species on leguminous plants were investigated by Sprague (12). In cross-inoculations, *Ascochyta pisi* from pea was able to infect many species of *Vicia*, including broad bean, and the *Ascochyta pisi* from broad bean was able to infect 7 out of 10 species of *Vicia*, including *V. atropurpurea*, *V. cracca*, *V. dasycarpa*, *V. ervilia*, *V. monanthis*, *V. villosa*, and *V. sativa*. The cultural characters were very similar for the *Ascochyta pisi* isolated from peas and from beans. The spores of the fungus from broad bean were larger than those of the fungus from pea. Relative to the spore size of *Ascochyta* on leguminous plants, Sprague has pointed out that there are transitional types between those on pea and those on broad bean. He also showed that the difference of symptomatology produced by *A. pisi* from broad bean on other vetches from that produced by *A. pisi* from pea was due to host reaction. As a result of this investigation, Sprague considered that most of the *Ascochyta* species on *Vicia* in North America are similar to or identical with *A. pisi* Lib. on peas and that the species on broad bean is a form of *A. pisi* resembling *A. fabae*.

Rathschlag (9) studied the *Ascochyta* parasitizing broad beans in Germany. The symptoms produced by his fungus corresponded on the whole to the "dark type" produced by *Mycosphaerella pinodes* (Berk. and Blox) Stone while the light-colored center of the lesion more closely resembled the "light-type" produced by *A. pisi*. In cross-inoculations, Rathschlag found that the fungi on pea and on broad bean were able to attack each other's hosts, but infection was uniformly more severe on the host from which the fungus was originally isolated. Thus there was a certain degree of specialization, but by no means a strict one within the fungus. Regarding spore size, he found that when *A. pisi* from pea was grown on broad bean, spores were slightly larger than they were on pea; when the fungus from broad bean was grown on pea, the spores were small.

Sattar (10) studied the fungi associated with blight of certain cultivated leguminous plants in India. Although no *Ascochyta pisi* isolated from broad bean was included in his investigation, he supported Sprague's view that the form on broad bean is a variety of the *A. pisi* Lib. occurring on peas.

On the other hand, Ludwig (5) inoculated species of *Phaseolus* and *Vicia* with *Ascochyta pisi* from peas and obtained uniformly negative results except on peas. On broad bean the fungus produced bluish spots with no trace of mycelium or spores.

SYMPTOMS OF THE DISEASE

The fungus attacks the leaves, stems, and pods of broad beans in the field. On the leaves, the spots are large, definite, circular to oblong, 2–22 × 2–16 mm. in diameter, with light-colored center and a dark or red border. They may be zonate and irregular, with a tendency toward shot-hole. The color

of the center of the spot is influenced to a certain extent by environment. In a dry season, as in Yunnan, the center is almost white. Under moist conditions, it may be gray or dirty white. In general, it is a light color. Spots occur at any point on the leaf surface. Sometimes the leaf tissue outside of the spot proper is blackened to form large dead areas of various size. Spots may also coalesce. In dry seasons, the affected leaves have a general yellowing, or plants are more or less defoliated.

Spots on leaves are at first dark brown, but soon develop the light center and dark red border. Pycnidia then develop and are either scattered over the spot or arranged in circles on the light center. They are reddish-brown

FIG. 1. Spots produced by *Ascochyta pisi* on leaves of broad bean in the field.

and very prominent. The various symptoms produced by the fungus on the leaves are shown in figures 1 and 3.

On stems, the lesions (Fig. 2) are circular, elongate, or oval, with gray centers and red margins. They are usually deeply sunken in the host tissue. Sometimes, large black areas without distinct demarcations occur. The lesions may attain a length up to 25 cm. In severe cases, stems are broken and die. Pycnidia are scattered over the diseased areas.

Spots on the pods (Fig. 2) are circular or oval and dark brown with black edges. They are usually deeply sunken in the host tissue. Lesions on the line of dehiscence of the pod are usually oval or a short spindle shape. Sometimes, lesions may assume such dimensions as to involve a large portion of the pod. When the attack of the fungus is severe, the pods shrivel. Consequently, only small immature seeds are produced. Diseased seeds may

be shrivelled or of greatly reduced size, dependent on the stage of development at which they are attacked by the fungus. Brown or black lesions are on the seed coat and severely infected seeds usually germinate poorly.

THE CAUSAL FUNGUS

The mycelium of the fungus within the host tissue varies greatly in

FIG. 2. Lesions produced by *Ascochyta pisi* on pods and on stems of broad bean in the field.

diameter. Hyphae are usually intracellular, but sometimes intercellular. On culture media they are hyaline and richly branched.

Pycnidia, which occur gregariously at the center or in circular zones on the spot, are prominent, globose-depressed, light brown, ostiolate, and 95–270 × 111–301 μ in diameter, with the average being 172 × 178 μ. Spores are oblong, straight or sometimes curved, hyaline, 1- or rarely 2- or 3-septate, and measure 1.4–30.4 × 3.8–7.9 μ, with an average of 17.9 × 5.9 μ. The perfect stage of the fungus has not been observed.

Conidia germinate very rapidly in water at 20° C. More than 95 per cent of the spores germinate within 24 hr., by the production of germ tubes from one or both cells either simultaneously or in succession. Within 48 hr. as many as 4 germ tubes were observed coming from a single spore. Conidia germinate over a wide range of temperature, from 14° to 32° C. The optimum was about 22° C.

CULTURAL CHARACTERS

The growth of the fungus was moderate on both the tube and plate cultures. Pycnidia were produced on all of the media tested and were especially abundant on broad bean-seed agar and sterile broad-bean stems and pods. Cultures that originated from spores produced pycnidia more readily

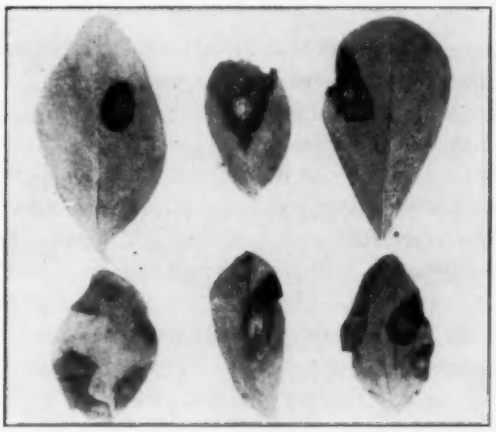

FIG. 3. Leaf spots produced by *Ascochyta pisi* in dry seasons. Note the white centers.

than those originating from mycelium. With consecutive transfers of the fungus from mycelial cultures the pycnidia became more sparse.

Growth in oatmeal-agar tubes was moderate, compact, and olivaceous green. On cornmeal agar, the growth was less compact. Scanty grayish white growth was found on broad-bean agar. On potato-dextrose agar, the growth was moderate, compact, and green. The substratum turned amber. On sterile broad-bean stems and pods, the growth was usually less abundant. It was gray, olivaceous, or light salmon.

Conidia produced in artificial culture agreed fairly well in size with those produced on the naturally infected host, while pycnidia had great variations. The pycnidia produced on cornmeal, broad-bean-seed, and potato-dextrose agars averaged respectively 246×217, 307×286, and 246×241 μ.

RELATION OF TEMPERATURE AND pH TO THE FUNGUS GROWTH

In order to determine the optimal temperature for the development of mycelium, transfers were made to potato-dextrose-agar plates placed at temperatures ranging from 4° to 35° C. The fungus grew best between 20°

and 26° C., with the optimum being around 25° C. The maximum was about 32–33° C. and the minimum about 8° C.

A series of liquid media with pH ranging from 2.4 to 10 was prepared by the electrometric method. Mycelial transfers of the fungus were made to 50-ml. Erlenmeyer flasks containing 20 ml. culture fluid. The flasks were incubated at 25° C. After 9 days, the dry weight of the mycelium was determined and the average weight of 4 flask cultures representing each pH value were computed. The results indicated that a pH of 6.8 was optimal for the growth of the fungus, although moderate growth was observed up to pH 8. On the other hand, the growth rate fell rapidly towards the acid side. The fungus grew over a wide range of pH, from 3.8 to 9.

INOCULATION EXPERIMENTS

Spores from pure cultures were sprayed over the plants, in water suspension. The inoculated plants were kept in a moist chamber for at least 24 hours. The time required for the spot to appear after inoculation in the greenhouse was 4 to 7 days. The disease first appeared as tiny deep red spots which enlarged rapidly and differentiated into light centers and dark red borders. Pycnidia were soon produced at the center of the spots. Stems, pods, and petioles were readily attacked by the fungus. Inoculation of the root by mixing the mycelial growth with soil was unsuccessful.

Numerous inoculations made from 1934 to 1936 and again from 1940 to 1942 showed that the fungus was very virulent on broad bean. When too heavy a spore suspension was sprayed over young bean seedlings, they might be killed in a short time. Many full-grown plants were also killed by the fungus, either from the blight of leaves or the death of the stems.

From time to time, the fungus isolated from broad bean was inoculated to growing plants of *Phaseolus vulgaris* L., *P. angularis* L., *Glycine max* Merr., *Pisum sativum* L., *Vicia sativus* L., and *V. villosa* Roth. In all cases results were negative. Special attention was paid to the pathogenicity of this fungus to peas, which, according to Rathschlag (9), were susceptible to *A. pisi* from broad bean. However, the writer was unable to cause infection on peas with his broad-bean fungus. The fungus sometimes produced tiny red lesions on *Vicia sativus*, but the lesions remained small and never produced the fructification of the fungus.

The results of these experiments indicated that the *Ascochyta pisi* occurring on broad bean in China is highly specialized to *Vicia faba*.

OVERWINTERING OF THE FUNGUS

In the spring of 1933, diseased leaves, stems, and pods were collected and were placed in a layer about 2 inches thick over the surface of soil in large wooden boxes left outdoors. In the course of winter and spring, these boxes were taken into the laboratory and planted with broad-bean seeds coming from healthy pods. Twenty-five seeds were planted in each box and sufficient water was added daily to keep the soil moist. On January 15,

1934, spots first appeared on the lower leaves of the seedlings. Fifteen out of 125 seedlings were killed by blight of the leaves and death of the shoots at the end of February. The rest of the seedlings had lesions on the aerial parts of the plants. The experiment was repeated in the following year and the same results were obtained.

In the course of these experiments, the diseased stems and pods were brought into the laboratory from time to time and examined under the microscope. Pycnidia either with or without exuding spore masses had been observed. Conidia germinated readily in water and when healthy seedlings were inoculated with them, disease lesions appeared.

In the fall of 1933, one hundred seeds with typical lesions on their seed coats were planted in wooden boxes under moist conditions. Ninety-three seeds germinated and three of them had disease lesions on the lower stem portions. Pycnidia were observed on the cotyledons of one seedling. Forty-three seedlings produced spots on the leaves when seedlings had attained a height of 5 to 8 inches. It was, however, difficult to trace out whether the source of infection was primary or secondary. Seedlings from the healthy seed were not infected.

It is evident that *Ascochyta pisi* may persist on dead stems and pods and may also remain in the seed coat in the form of dormant mycelium until the seed germinates, when the fungus then forms pycnidia.

DISCUSSION

On account of the substantial agreement in symptomatology, and morphologic characters of the *Ascochyta* species described in this paper to that of *A. pisi* on the same host described by Sprague (12) and Rathschlag (9), it is reasonable to consider the fungus on broad bean in China as *A. pisi* Lib., the species that occurs on peas. Difference was noted, however, in pathogenicity, because the present fungus has been unable to attack *Pisum sativum* and two species of *Vicia*, while the fungus described by Sprague in North America and by Rathschlag in Germany had a wider host range. It has been shown that the *Ascochyta pisi* on *Vicia* species (12) as well as on pea and broad bean (9) are specialized to a certain degree and it is difficult to draw a specific distinction between them from the standpoint of their pathogenicity. Accordingly, a difference in host range is of little importance. Until a critical comparison between the *Ascochyta* species isolated from broad beans of various sources and extensive cross-inoculation experiments with a large number of pea varieties have been made, it is justifiable to consider the present fungus, which is highly specialized on broad bean, as a variety of *A. pisi* Lib., and the name *A. pisi* Lib. var. *fabae* Sprague is proposed for it.

SUMMARY

1. Ascochyta blight, and leaf and pod spot, of broad bean has been found in many bean-growing regions in China. Under favorable conditions, it may cause heavy losses to the crop.

2. The morphology, physiology, cultural characters, and methods of overwintering of the fungus have been studied.

3. Inoculations show that the fungus is not able to infect peas and a few species of *Vicia*. It is thus highly specialized on broad bean.

4. From the experimental results in relation to taxonomy of the fungus the author concludes that the present fungus is a variety of the *Ascochyta pisi* that occurs on peas, and the name *A. pisi* Lib. var. *fabae* Sprague is proposed for it.

THE UNIVERSITY OF NANKING,
NANKING, CHINA.

LITERATURE CITED

1. AGOSTINI, A. Contribuzione alle flora micologica del Senese. Arch. Bot. Sistematica **1**: 221–245. 1925.
2. CABALLERO, A. Adiciones a la microflora Española. Bol. R. Soc. Española. Hist. Nat. **28**: 421–430. 1928.
3. IDETA, A. Hand-book of the plant diseases of Japan. Ed. 4. Shokwabo, Tokyo. 1911.
4. LIBERT, M. A. Plantae cryptogamicae, quas in Arduenna collegit. Leodii, Cent. 1. 1830.
5. LUDWIG, O. Untersuchungen an *Ascochyta pisi* Lib. Beitr. Biol. der Pflanzen **16**: 464–510. 1928.
6. MCDONALD, J. Annual report of the senior mycologist. Rept. Dept. Agr. Kenya (1934) **2**: 24–39. 1936.
7. NATTRASS, R. M. Annual report of plant pathologist for the year 1936. Rept. Dir. Agr. Cyprus (1936): 50–56. 1937.
8. PETHYBRIDGE, G. H. Fungus and allied diseases of crops 1925, 1926 and 1927. Gt. Brit. Min. Agr. and Fish., Misc. Publ. 70. 1929.
9. RATHSCHLAG, HEINZ. Zur Spezialisierung der auf *Vicia faba* parasitierenden *Ascochyta*. Phytopath. Zeitschr. **2**: 493–501. 1930.
10. SATTAR, A. A comparative study of the fungi associated with blight diseases of certain cultivated leguminous plants. Trans. Brit. Myc. Soc. **18**: 276–301. 1934.
11. SPEGAZZINI, C. Fungi Argentini. Anales Museo Nacional Buenos Aires **6**: 81–365. 1899.
12. SPRAGUE, RODERICK. Host range and life-history studies of some leguminous *Ascochytae*. Phytopath. **19**: 917–932. 1929.

NUTRITION OF THE TREES AND DEVELOPMENT OF DUTCH ELM DISEASE

K. G. Parker, L. J. Tyler, D. S. Welch, and Seth Pope[1]

(Accepted for publication December 19, 1946)

Observations in the field on the Dutch elm disease have indicated that elm trees in high, moderate, and low vigor are susceptible to the disease (3). Where differences in susceptibility have been reported the observations were that rapidly growing trees were somewhat more severely diseased than were slowly growing ones. Buisman (2) observed this difference where part of the trees were induced to grow more rapidly by pruning.

Considerable importance is attached to keeping elm trees in reasonably good condition in order to prevent the breeding of bark beetles. This, of course, would help in keeping down the population of the beetles. More important is the prevention of inoculations with *Ceratostomella ulmi* (Schwarz) Buis. by bark beetles attracted to the trees, or by the progeny of these beetles. The question immediately arises as to whether the maintenance of a tree in condition to prevent beetle breeding might result in its being more likely to be destructively affected by the disease if it should be inoculated.

Went (7) obtained less development of the Dutch elm disease on potted trees given a full nutrient treatment and supplied with extra potassium than on those given the full nutrient treatment only. Banfield (1) grew trees in sand and supplied a full nutrient solution. Less dieback resulted on these than on trees treated similarly but with nitrogen withheld. On the other hand, if he pruned the trees heavily, with a resultant very long and succulent shoot growth, those which received nitrogen were more severely diseased than were those which did not. May (4) attributed the different responses in these trees to different carbohydrate-nitrogen ratios. Zentmyer and Wallace (8) stated that trees that responded well to nitrogen fertilization were less severely affected than were others.

MATERIALS AND METHODS

Trees of the species *Ulmus americana* L. were used in all experiments. In experiment 1 they were 2-year-old budded trees of the Princeton variety. For the other two experiments, cuttings were rooted from a clonal selection made by the Jackson and Perkins Nursery, Newark, New York. The trees

[1] The writers wish to express special thanks to Dr. M. M. McCool, Boyce Thompson Institute for Plant Research, who gave very generously of his time in supplying information on soils and methods of treating them. The work involved a field relatively unfamiliar to those doing the work and Doctor McCool's able counsel and advice made it possible to carry on the study.

Several individuals assisted with the work from time to time. Those making the most substantial contributions were Dr. William F. Mai and Dr. W. L. White.

Dr. L. H. MacDaniels provided very helpful advice on methods of handling and fertilizing potted trees.

used in the last two experiments were grown from cuttings rooted in 1936, with the experiments started in 1938 and in 1939, respectively.

The trees were potted in 18-quart galvanized pails in a very poor Gloucester loam soil, about 17 kilograms per tree. This soil was so poor that not more than traces of nitrogen, phosphorus, and potassium could be detected by the "quick test" methods of analysis used in this study. The pH of the soil when collected from the field usually was about 5 to 5.5. Subsoil was used in experiment 1 and topsoil in the other two experiments.

At the time of planting any phosphorus or potassium materials to be added were mixed in the soil for each tree before it was potted. Nitrogen compounds were stirred into the top two inches of soil after potting. Where the entire complement of nitrogen was to be supplied in the form of a chemical compound, only one-half of the amount was applied at potting. The remainder was added three to four weeks later. The entire complement of potassium or phosphorus was applied in the initial treatment. Where manure was used the entire treatment was made at potting, including all of the nitrogen.

The pails were sunk into the ground to the depth of the soil inside and were spaced in rows so that the trees were 18 or 24 inches apart, depending on their size.

After the first year in any given experiment treatments were made similarly to those at the outset. The first treatment was made about the time growth started in the spring and the materials were stirred into the top three to four inches of soil. The second application of nitrogen was made three to four weeks later.

During the summer months water was applied as needed. The soil was stirred every week or two to help maintain it in good tilth.

The trees were pruned at planting and in the spring one year later. Those in experiments 1 and 2 were pruned very moderately and those in experiment 3 somewhat more heavily. No pruning was done after the inoculations were made. Toward the end of each growing season, and at the termination of the experiment, soil was collected from experiments 2 and 3 for analysis and pH determination. The top one-half inch of soil was removed and a hole about four inches deep dug with a trowel. The sample was taken by scraping with the trowel along the sides of the hole, taking care to obtain soil from top to bottom. Each test sample was a composite of two taken from opposite sides of a single tree. At the termination of the experiment all of the soil was removed and a second sample taken from the entire mixed soil contents of the individual pail. Tests were made at once on the fresh soil; or it was spread out to dry, then stored in paper bags in an office, away from any laboratory fumes, until tests could be made.

Hydrogen-ion determinations were made by means of a Beckman pH meter, model G, using the 5-inch glass electrodes designed especially for work with heavy suspensions. The soil was mixed with distilled water in the ratio of 1 to 5 or 1 to 2.5, and the suspension was stirred vigorously for one minute with the electrodes in it before the reading was taken.

Analyses for nutrients were made by means of the quick tests developed by Morgan (5). Morgan described a modification of these tests in a later publication, but his earlier methods were followed throughout for uniformity.

Relative growth rates sometimes were determined by measuring the total length of all current season's shoots on each tree. In part of the experiments the fresh weight of each tree was taken at the beginning and at the end. Also, the thickness of the annual rings in the wood was measured at the time the trees were cut for examination.

In the second year of each experiment, the trees were inoculated by the method described by Tyler (6). The spore suspension of *Ceratostomella ulmi* was injected on opposite sides of the trunk just below the first branch. This was done after considerable growth had been produced but while shoot length was being extended, usually about June 1. Examinations for wilt and defoliation were made at various intervals during the summer, depending on the rate of development of symptoms.

At the end of the second growing season, the year in which the trees were inoculated, the trees in experiment 1 were removed from the pails, the soil removed from the roots, and various examinations made for severity of disease development on each tree. The trees in experiment 2 were not examined until the spring two years after they were inoculated and those in experiment 3 were examined in October, one and one-half years after they were inoculated.

The extent of invasion by the pathogen was determined by measuring the distance disease discoloration extended from the inoculation point. Also, the total length of the trunk and main branches and the portion of each that had been killed were measured.

Sufficient cultures were prepared to make sure that the trees were affected by the Dutch elm disease and that the discoloration present was caused by that disease.

Experiment 1 was designed to test the influence of an inorganic fertilizer treatment containing nitrogen, phosphorus, and potassium singly, and in all possible combinations, on the development of the disease. Nitrogen was supplied in the form of sodium nitrate, phosphorus as superphosphate, and potassium as potassium sulphate. The complete treatment contained these elements in the ratio of 5–10–5, nitrogen expressed as N, phosphorus as P_2O_5, and potassium as K_2O. In the second year, only the nitrogen was supplied, since spectroscopic analyses[2] made on soil from several of the trees indicated phosphorus and potassium were present in abundance. The nitrogen application was reduced by one-half that year because some nitrogen injury to the leaves had appeared the first season.

The treatments were as listed in table 1.

The trees were potted on April 22 and 23, 1935, and the experiment was terminated in October, 1936.

Since the results of experiment 1 showed a definite need for a complete

[2] Analyses kindly made by Dr. M. M. McCool.

TABLE 1.—*Formulae and materials applied to trees in experiment 1 the first year*

Treatment	Formulae	Materials, in grams per tree		
		Sodium nitrate	Superphosphate (16 per cent P_2O_5)	Potassium sulphate
1 (check)	0–0–0	0	0	0
2 (NPK)	5–10–5	56	112	18
3 (K)	0–0–5	0	0	18
4 (N)	5–0–0	56	0	0
5 (P)	0–10–0	0	112	0
6 (PK)	0–10–5	0	112	18
7 (NK)	5–0–5	56	0	18
8 (NP)	5–10–0	56	112	0

fertilizer treatment, experiment 2 was designed to test different formulae (Table 2). Also, the effects of different hydrogn-ion concentrations in the soil and the addition of minor elements were studied in this experiment.

The trees were planted in April, 1938. Since analyses made in October, 1938, indicated only moderate amounts of available nutrients left in the soil, the same formulae were used in 1939 as in the first year, with the following exceptions: No lime was applied to trees in treatment 5. The amounts of N, P_2O_5, and K_2O supplied to all trees were increased to $1\frac{1}{4}$ times that used in 1938 because of the greater size of the trees.

In 1940 the soil treatments were the same as those made in 1939 except that no minor elements were added to the trees in treatment 6.

The trees were cut and results recorded on May 13 to 16, 1941. No soil treatments were made in 1941.

TABLE 2.—*Formulae and materials applied to trees in experiment 2 the first year*

Treatment	Formulae	Materials, in grams per tree		
		Sodium nitrate	Superphosphate (20 per cent P_2O_5)	Potassium sulphate
1 (check)	0–0–0	0	0	0.0
2	5–10–5	20	32	6.4
3	10–10–5	40	32	6.4
4	6–8–3	24	25.6	3.8
5	5–10–5 (plus lime)[a]	20	32	6.4
6	5–10–5 (plus minor elements)[b]	20	32	6.4

[a] Forty-five grams ground limestone per tree added.

[b] Minor elements were added in solution, per tree as follows:

Compound	*Number of grams*	*Actual amount of element (gm.)*
$CuSO_4 \cdot 5H_2O$	0.1936	0.048 Cu
$MnCl_2 \cdot 4H_2O$	0.384	0.096 Mn
$Na_2B_4O_7 \cdot 10H_2O$	0.03	0.0036 B
$FeSO_4 \cdot 7H_2O$	0.432	0.096 Fe
KI	0.0624	0.048 I

Experiment 3 was designed to test 3 different nitrogen sources, different formulae, and two levels of treatment in a complete fertilizer. The experiment was started in 1939 and the treatments in 1940 and 1941 were the same as those in 1939. The formulae used are given in table 3. It was necessary

TABLE 3.—*Formulae and materials applied to trees in experiment 3 the first year*

Treatment number	Formulae	Materials, in grams per tree				
		Urea (42 per cent N)	Sodium nitrate	Superphosphate (20 per cent)	Potassium sulphate	Manure[a]
1 (check)	0–0–0	0.0	0	0	0.0	0
2	5–10–5	0.0	25	40	8.0	0
3	5–10–5	9.5	0	40	8.0	0
4	6–8–3	11.4	0	32	4.8	0
5	5–10–5	4.7	0	36	4.2	110
6	2 × (5–10–5)	19.0	0	80	16.0	0
7	2 × (6–8–3)	22.8	0	64	9.6	0

[a] Containing: N—1.85 per cent; P_2O_5—0.75 per cent; K_2O—1.75 per cent.

to change the amounts of materials applied in treatment 5 after the first year to compensate for a slightly different analysis of the manure used.

Final results on the trees in experiment 3 were recorded in October, 1941.

RESULTS OF EXPERIMENTS

Experiment 1

During the first year the best growth, as judged by their general appearance, occurred in the trees which received treatment 2, the complete fertilizer (Table 4). Next best was treatment 8, nitrogen and phosphorus. There were some leaves with brown edges in all treatments, including the check. A part of this injury probably was caused by the fertilizers; but it was not possible to assign the injury to particular elements, or to assess its severity. Again in 1939 treatment 2 was best, with shoot lengths in treatment 7 good but color of leaves becoming poor during the summer. Treatment 8 was next to treatment 2. All others were poor; however, there was no definite fertilizer injury evident in any treatment.

In experiment 1 the least wilt and the least extensive invasion of the trees occurred in the trees which received the complete fertilizer. Next in order was the treatment of nitrogen and phosphorus, and third was the nitrogen-potassium combination. Other treatments were little, if any, better than the nonfertilized control. These results were correlated inversely with the amount of growth, the greater the growth the less was the disease development.

Experiment 2

Growth on the trees was uniformly good except on the nonfertilized controls (Table 5). Fertilizer injury to the leaves became evident by August, 1939. It was most severe on treatments 3, 4, and 6, moderate on 2, and least

on 5. There was no clear indication of relationship with the different materials applied with the possible exception that lime may have prevented the injury to some extent. Likewise, growth was somewhat greater on the trees that received lime.

The pH of the soil in August, 1938, ranged between 5.8 and 6.0 in all treatments except that including lime, in which it was 6.6. At the end of the experiment similar relationships held, but the hydrogen-ion concentration in the sample taken from the composite sample of all soil in the pail was markedly higher than that in the surface soil sample. All nutrients usually fell in the medium range in the treated soils and in the low range in the nonfertilized controls.

TABLE 4.—*Severity of disease development and growth of trees in experiment 1. Each figure is the average from 6 trees, inoculated June 3, 1936*

Treatment	Thickness of annual rings		Leaves affected[a]		Discoloration[d]	Dead wood in main branches[a]
	1935	1936	Greatest amount observed[b]	Observed Aug. 17, 1936[c]		
	Mm.	*Mm.*	*Per cent*	*Per cent*	*Inches*	*Per cent*
1 (check)	0.5	0.4	85.8	75.8	29.2	22.5
2 (NPK)	0.7	1.5	15.8	9.2	4.3	3.3
3 (K)	0.6	0.3	89.2	68.3	21.7	30.8
4 (N)	0.5	0.4	82.5	65.0	20.4	22.2
5 (P)	0.4	0.5	90.0	85.8	27.1	8.3
6 (PK)	0.4	0.5	71.7	60.8	18.6	22.2
7 (NK)	0.4	0.7	58.2	31.2	17.8	5.0
8 (NP)	0.5	1.0	47.5	21.3	14.6	0.3

[a] Estimated, expressed as percentage.

[b] Amount of leaves wilted varied from time to time and recovery was definitely observed. Hence greatest amount wilted during the summer on most trees was greater than that on August 17.

[c] Last date when observations on wilt were made.

[d] The discoloration extended downward from the point of inoculation.

In order to save space in table 5 data on weight of the trees are not given. Differences in weight corresponded very closely with those in total length of the 1938 shoot growth.

Based on amount of wood killed, the least disease development occurred in treatment 3, with the 10–10–5 fertilizer formula. There was little to choose from, however, among the treatments except that the trees receiving lime were more severely affected. All treatments were much better than the check.

Experiment 3

As in the previous experiment, growth of the trees in this test was generally good except in the nonfertilized control group (Table 6). No injury attributed to the fertilizer treatment was noted at any time.

The pH of the soil in this experiment was generally similar to that in experiment 2. Where part of the nutrients were supplied in the form of

TABLE 5.—*Measurements of growth and disease development in experiment 2. Trees inoculated May 29, 1939*

Treatment number	Fertilizer formulae	Total length 1938 shoots, av. per tree in inches	Wilt in 1939, av. per tree [c]		Condition of wood[e] in May, 1941					
					Trunk			Main branches		
						Dead wood			Dead wood	
			Greatest amount observed	Observed July 5[d]	Total inches	Inches	Per cent	Total inches	Inches	Per cent
1[a]	Check	50	86.7	78.3	237	116	48.9	287	247	86.1
2[a]	5–10–5	180	30.8	26.8	260	16	6.2	809	172	21.3
3[b]	10–10–5	176	38.5	27.0	197	0	0.0	568	71	12.5
4[a]	6–8–3	173	30.0	18.7	265	22	8.3	697	141	20.2
5[a]	5–10–5 (plus lime)	190	50.4	34.4	288	21	7.3	608	201	33.1
6[a]	5–10–5 (plus minor elements)	147	34.8	28.9	252	10	4.0	584	98	16.8

[a] 12 trees in treatment.
[b] 10 trees in treatment.
[c] Estimated percentages.
[d] Observations at later dates not reliable because of fertilizer injury.
[e] Data given are sums of measurements of all trees.

TABLE 6.—*Measurements of growth and disease development in experiment 3.*[a] *Trees inoculated May 30, 1940*

Treatment number	Fertilizer formulae	Total length 1939 shoots, av. per tree in inches	Wilt in 1940, av. per tree[e]		Condition of wood[f] in October, 1941					
					Trunk			Main branches		
			Greatest amount observed	Observed July 31	Total inches	Dead wood		Total inches	Dead wood	
						Inches	Per cent		Inches	Per cent
1	Check	65	98	92	211	105	49.8	264	256	97.0
2	5–10–5[b]	138	93	85	194	43	22.2	314	225	71.7
3	5–10–5[c]	200	86	79	227	43	18.9	301	220	73.1
4	6–8–3[c]	194	80	74	214	70[g]	32.7	339	238	70.2
5	5–10–5[d]	177	81	79	208	41	19.7	361	205	56.8
6	2 × (5–10–5)[c]	229	94	86	197	104[h]	52.8	374	316	84.5
7	2 × (6–8–3)[c]	188	89	85	201	90[g]	44.8	340	259	76.2

[a] 10 trees in each treatment.
[b] Nitrogen source was sodium nitrate.
[c] Nitrogen source was urea.
[d] Dried cow manure included, with remainder of nitrogen supplied as urea.
[e] Estimated percentages.
[f] Data given are sums of measurements of all trees.
[g] Two trees entirely dead.
[h] Four trees entirely dead.

cow manure the hydrogen-ion concentration was lower than it was in the other treatments, particularly at the end of the experiment. In the nonfertilized controls the hydrogen-ion concentration at the end of the experiment was markedly higher than in the treated soils.

Nutrients in the treated soils were generally in the high range throughout, and in the nonfertilized controls they were always low.

There was more dead wood in the trees which received the 6–8–3 fertilizer formula than the 5–10–5. Two trees which received the 6–8–3 treatment were completely killed and two were killed in the $2 \times (6–8–3)$ treatment. Four trees which received the double amount of 5–10–5 were killed (treatment 6). It seemed to make little difference in this experiment whether the nitrogen was supplied in the form of sodium nitrate, urea, or a mixture of urea and barnyard manure. All (applied in the 5–10–5 formula, smaller amount) were equally good, much better than the check, and appreciably better than the 6–8–3 formula or the double dosage of the 5–10–5 formula.

More severe disease development occurred generally in this experiment than with comparable soil treatments in experiment 2, probably because of the heavier pruning these trees received. These results are in agreement with those of Banfield (1) and of Buisman (2).

DISCUSSION

It seems fairly clear that elm trees may be maintained in good growing condition without inducing unusually severe development of the Dutch elm disease in inoculated individuals. The indications are that soil treatments should not be excessive and should be well balanced. However, specific fertilizer formulae cannot be devised on the basis of the information available. Pruning of the trees should be kept at a minimum.

Nitrogen obviously is necessary but care should be exercised in the amounts applied. Of particular significance is the apparent need for phosphorus. These experiments indicate a very definite benefit from phosphorus in aiding the tree to survive when diseased. Potassium appears to be of less importance but was beneficial in a treatment for the very poor soil used in this study.

Experiments were made on larger trees planted in the open, with the results similar but the differences not so large. That is, growth differences were less, as were differences in disease development. However, when a good response to a complete fertilizer treatment was obtained, the trees were less severely affected by the Dutch elm disease than were the nonfertilized and more poorly growing check trees.

Therefore, there appears to be no danger in keeping trees in a good growing condition so long as they are not pruned too heavily and a succulent type of tissue is not produced. Probably a complete fertilizer, not very high in nitrogen, should be used until further investigation has determined more accurately the requirements of a good treatment.

In one experiment the hydrogen-ion concentration was reduced by the

addition of lime to the soil, and greater disease development resulted. In other tests the hydrogen-ion concentration in the soil was less in the better treatments than in the checks. Obviously, the influence of pH of the soil on the development of this disease cannot be determined on the basis of these experiments, but it appears to deserve further study.

SUMMARY

Experiments with small trees potted in subsoil indicated that a complete fertilizer treatment may result in less severe disease development in trees infected by the Dutch elm disease pathogen. Nitrogen and phosphorus seemed to play a major rôle, with potassium in a secondary position but, nevertheless, important.

Among the various nitrogen sources tried, in experiments using topsoil, there were no definite differences.

Excessive amounts of fertilizer, over that required to support good growth, may be undesirable.

Pruning sufficiently heavily to induce very succulent shoots resulted in increased disease development.

There was some indication that differences in disease development may result, directly or indirectly, from differences in hydrogen-ion concentration in the soil.

CORNELL UNIVERSITY,
ITHACA, NEW YORK.

LITERATURE CITED

1. BANFIELD, W. M. Effect of nitrogen on inception and development of Dutch elm disease on American (Moline) elm. (Abstr.) Phytopath. **28**: 2–3. 1938.
2. BUISMAN, CHRISTINE. Verslag over de onderzoekingen betreffende de iepenziekte, verricht in het phytopathologisch laboratorium "Willie Commelin Scholten" te Baarn, gedurende 1934. Tijdschr. over Plantenz. **41**: 104–120. 1935.
3. MAY, CURTIS. Outbreaks of the Dutch elm disease in the United States. U. S. Dept. Agr. Circ. 322. 1934.
4. ———. Host-parasite relations of *Ceratostomella ulmi*. (Abstr.) Proc. Third Int'l. Cong. for Microbiol. 1939: 530–531. 1940.
5. MORGAN, M. F. The Universal soil testing system. Connecticut Agr. Exp. Sta. Bul. 392: 129–159. 1937.
6. TYLER, L. J. Influence of temperature on the Dutch elm disease in potted American elm. Phytopath. **35**: 302–304. 1945.
7. WENT, JOHANNA C. Verslag van de onderzoekingen betreffende de iepenziekte, verricht op het phytopathologisch laboratorium "Willie Commelin Scholten" te Baarn, gedurende 1936. Tijdschr. over Plantenz. **43**: 75–90. 1937.
8. ZENTMYER, GEORGE A., and PHILLIP P. WALLACE. Factors influencing the development of *Ceratostomella ulmi* in elm trees. (Abstr.) Phytopath. **34**: 1014. 1944.

BACTERIAL LENTICEL INFECTION OF EARLY POTATOES

M. A. Smith[1] and G. B. Ramsey[2]

(Accepted for publication December 20, 1946)

Many of the previous extensive investigations on bacterial soft rot of potatoes have been concerned chiefly with tubers showing decay following mechanical injuries or heat injury (scald) during harvesting, transit, and storage (3, 11, 12, 13, 14, 15, 16, 17). While bacterial lenticel infection of potatoes has been reported (13, 18, 19), no critical study has been made of the types of injury and decay resulting from such infections, the conditions under which such infections occur, or the identity of the organisms involved. This paper is the result of studies since 1942 of bacterial lenticel infection of early potatoes and is concerned primarily with the pathogenicity of isolates from lenticels and other sources, the pathological histology of the host, and the physiological characteristics of the organisms involved.

Observations of early potato shipments arriving on the Chicago market since 1935 reveal that bacterial infection of potatoes through lenticels has been an important factor in the incidence of bacterial soft rot (13), particularly since the washing of potatoes has become common practice.

Cars of potatoes arriving on the Chicago Produce Terminal in such poor condition as to require reconditioning before they can be sold, are shifted to a special track and unloading platform. A careful check of many of these cars during the past 4 years shows that bacterial soft rot is the most important cause of decay. Some carlots have so much decay as to make necessary the sorting of potatoes in all bags. In many cars, however, most of the bags with excessive decay are in the warmest and poorest ventilated part of the load, halfway between doorway and bunkers at each end of the car. Shipping tests have shown that this part of the load is most likely to decay (14).

In 1942 a survey of 132 carlots of potatoes reconditioned in Chicago showed that loss on account of bacterial soft rot ranged from 2 to 98 per cent. Losses of 1000 to 10,000 lb. were common, and in many lots 15,000 to 24,000 lb. out of a 30,000-lb. load were worthless. Most of these shipments originated in States having excessively wet weather before and during harvesting, and most of the decay that followed originated at lenticels. Table 1 shows the percentage of decay found on reconditioning some lots of early potatoes from various States.

Decay of potatoes following lenticel invasion by bacteria is usually more serious in stock grown in wet or heavy soils than in light soils. Soft-rot bacteria have been isolated from lenticels that appeared normal as well as from enlarged and proliferated lenticels. The universal presence of soft-

[1] Associate Pathologist, [2] Senior Pathologist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture. In cooperation with Dept. of Botany, University of Chicago.

The writers acknowledge the assistance of Barbara C. Heiberg who prepared the slides from which the photomicrographs were made.

rot bacteria in soil makes possible the invasion of lenticels previous to harvesting while subsequent temperature, moisture, and handling conditions determine whether or not decay eventually develops. As is well known, tubers grown in heavy or wet soils often have greatly proliferated lenticels and bacterial invasion often occurs in this proliferated tissue (Fig. 1, B). When these tubers are washed before shipment, the proliferated tissue is often rubbed off and the injured areas resulting are readily invaded by bacteria present in the wash water. Infected lenticels may remain as mere blemishes but bacterial soft rot often develops at such centers under favorable conditions. Warm potatoes, bagged wet, and loaded into non-refrigerated cars are under conditions most favorable for the development of extensive bacterial soft rot (14).

Lenticel infection is often characterized by raised, watersoaked areas, 3 to 5 mm. in diameter, around the lenticels (Fig. 1, A). The tissue in such

TABLE 1.—*Bacterial soft rot following lenticel infections and injuries in some typical lots of potatoes reconditioned on the Chicago Market in 1942*

Origin	No. bags	Date	Percentage of decay	
			Range	Average
Alabama	3955	May–June	5–50	14.6
Arkansas	526	June–July	10–21	15.2
California	3257	May–June	3–28	11.1
Kansas	2251	June–July	5–72	34.2
Louisiana	4592	May–June	2–70	13.9
Missouri	5865	June–July	7–93	46.5
Nebraska	2739	July–August	2–26	11.9
Oklahoma	1414	June–July	6–98	24.6

areas is usually firm. The swelling and watersoaking of the infected area is commonly observed in the varieties Bliss Triumph and Warba, and occasionally in Cobbler. When cross sections are made of infected areas, the tissues beneath appear watersoaked and gray to dark brown (Fig. 2, D). The depth of the infected area varies from 1 to 3 mm. Although lenticels of White Rose and Cobbler are often infected without showing evidence of swelling, tubers of both these varieties with swollen, infected lenticels are occasionally seen.

When drying occurs in the infected area around the lenticels the epidermis often becomes slightly sunken, although it generally remains intact (Fig. 1, C, D). Cross sections through the infected areas of such lenticels reveal that the outer periderm and the infected parenchyma cells beneath have become separated, resulting in the formation of a small cavity between them (Fig. 2, F). In the varieties Cobbler and White Rose the color of the epidermis over the lesions varies from gray to tan with a darker border. In the red-skinned varieties, such as Warba and Triumph, the infected area often appears bleached. Lenticel infections are often so numerous that they coalesce making individual spots indistinguishable (Fig. 1, D). Bacterial invasion of proliferated lenticels often appears as watersoaked, light

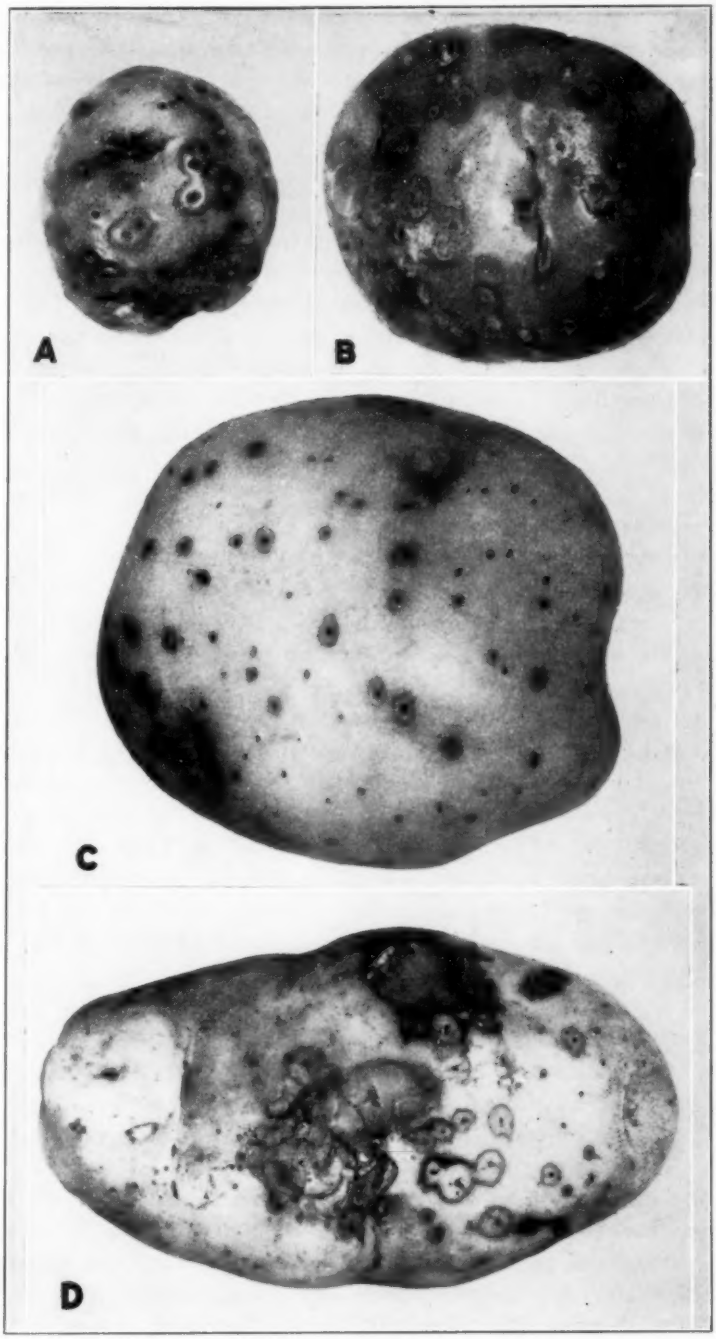

FIG. 1. A. Bacterial lenticel infection on Bliss Triumph potato tuber showing swollen areas around lenticels. B. Decay around enlarged lenticels on Bliss Triumph. C. Various stages of decay at lenticels on Cobbler. D. Lenticel infection on White Rose. Some lesions have coalesced resulting in advanced decay.

brown areas in the tissues in the immediate vicinity although it may extend 2 to 3 mm. around the lenticels (Fig. 1, B). The diseased area may extend into the tuber to a depth of 2 to 4 mm.

PATHOGENICITY

The bacterial isolates used in these studies were obtained from representative varieties of potatoes from the principal early potato producing sections of the United States. Isolations were made from lenticels, soil around tubers, tubers in advanced stages of soft rot, tubers in which rot was around mechanical injuries, and from tubers that were browned and had become sticky because of superficial bacterial growth in areas where the epidermis had been rubbed off. In the studies of infected lenticels, isolations were made from those having swollen, watersoaked areas around them (Fig. 1, A), sunken, decayed areas around lenticels (Fig. 1, C, D), and decay around proliferated lenticels (Fig. 1, B). Isolations from potatoes with advanced soft rot were made from the interior of tubers along the margin of the farthest advance of the decay.

The various isolates were tested for pathogenicity by needle puncture into potato slices or whole tubers. In the inoculation of lenticels by artificial means, noninjured tubers were allowed to remain in water suspensions of bacteria for various lengths of time, after which they were incubated in tightly sealed moist chambers.

The summary of the pathogenicity studies appears in table 2. With the exception of isolates from skinned, browned tubers that had become sticky, a relatively high percentage of the isolates from the different sources were pathogenic. The average percentages of pathogenic isolates from the different sources were as follows: Soil around tubers, 78.4; swollen, watersoaked areas around lenticels, 74.0; decay around proliferated lenticels, 71.9; sunken, decayed areas around lenticels, 60.0; tubers with advanced soft rot, 66.3; decay around mechanical injuries, 52.3; and sticky areas on browned tubers, 0.

During the studies, observations were made to determine if there were marked pathogenic differences among the various isolates. Cultures were used from isolation series 2, 4, 5, 6, 9, 10, 14, 16, 21, 22, 23, 27, and 30. This series included isolates from all of the different sources. The rapidity and extent of the rot in whole tubers was considered a measure of pathogenicity. The results of the tests indicated that there was much variation in the progress and extent of rot among isolates from different series and even among isolates from the same series. Some were strongly pathogenic, some moderately so, and others weakly pathogenic. Leach (10) found in studies with blackleg of potato that it was almost impossible to rot tubers with the blackleg pathogen by wound inoculations when tubers were given a constant supply of fresh air even though inoculated at the optimum temperature and in a saturated atmosphere. In the present studies soft rot readily occurred when inoculated tubers were placed in tin pails with

tightly fitting tops or in moist chambers of the desiccator type where the oxygen supply was not replenished.

Certain of the isolates that caused rapid rotting (Series 2, 6, 10, 16, 22, and 30) produced an extensive, soft, grayish-white decay of tubers. Isolates from other series induced a decay that varied from white to dark brown.

TABLE 2.—*Pathogenicity to potato of bacterial isolates from different sources*

Isolation series No.	Location and host variety	Isolates		
		Number	Source	Percentage pathogenic
1	Missouri—Warba	13	Swollen, watersoaked areas around lenticels	69.2
2	Do	19	Soil around tubers	73.6
3	Missouri—Cobbler	12	Do	83.3
4	Do	14	Decay around proliferated lenticels	64.2
5	Do	9	Tubers with advanced soft rot	66.6
6	Nebraska—Warba	6	Sunken, decayed areas around non-proliferated lenticels	50.0
7	Do	7	Swollen, watersoaked areas around lenticels	71.4
8	Do	18	Sticky areas on browned tubers	0
9	Do	12	Tubers with advanced soft rot	75.0
10	Nebraska—Cobbler	4	Swollen, watersoaked areas around lenticels	75.0
11	Florida—Triumph	16	Do	50.0
12	Kansas—Cobbler	8	Sunken, decayed areas around non-proliferated lenticels	62.5
13	Do	9	Decay around proliferated lenticels	77.7
14	Do	10	Decay around shatter bruises	50.0
15	Louisiana—Triumph	10	Swollen, watersoaked areas around lenticels	100.0
16	Do	6	Sunken, decayed areas around non-proliferated lenticels	66.6
17	Do	15	Decay around proliferated lenticels	73.3
18	Do	20	Tubers showing advanced soft rot	70.0
19	Texas—Triumph	18	Swollen, watersoaked areas around lenticels	66.6
20	Do	7	Sticky areas on browned tubers	0
21	Alabama—Triumph	12	Swollen, watersoaked areas around lenticels	91.6
22	Do	9	Sunken, decayed areas around non-proliferated lenticels	66.6
23	Do	16	Decay around shatter bruises	50.0
24	Do	13	Tubers showing advanced soft rot	53.8
25	Colorado—Cobbler	16	Swollen, watersoaked areas around lenticels	75.0
26	Do	17	Sunken, decayed areas around non-proliferated lenticels	64.1
27	Washington—White Rose	11	Do	63.6
28	Do	10	Swollen, watersoaked areas around lenticels	70.0
29	California—White Rose	20	Sunken, decayed areas around non-proliferated lenticels	50.0
30	N. Dakota—Triumph	14	Decay around cuts	57.1

None of the isolates from skinned tubers with sticky browned areas proved pathogenic. A study of certain of these nonpathogenic organisms revealed that they resembled *Bacterium coadunatum* (Wright) Bergey *et al.* (4) in certain morphological, biochemical, and physiological characteristics.

This organism was found by Brooks and McColloch (5) to be capable of producing stickiness in shelled green lima beans. It has been observed that under favorable conditions, such as high relative humidity and moderate temperature, bacterial soft rot may follow infection by some of the sticky

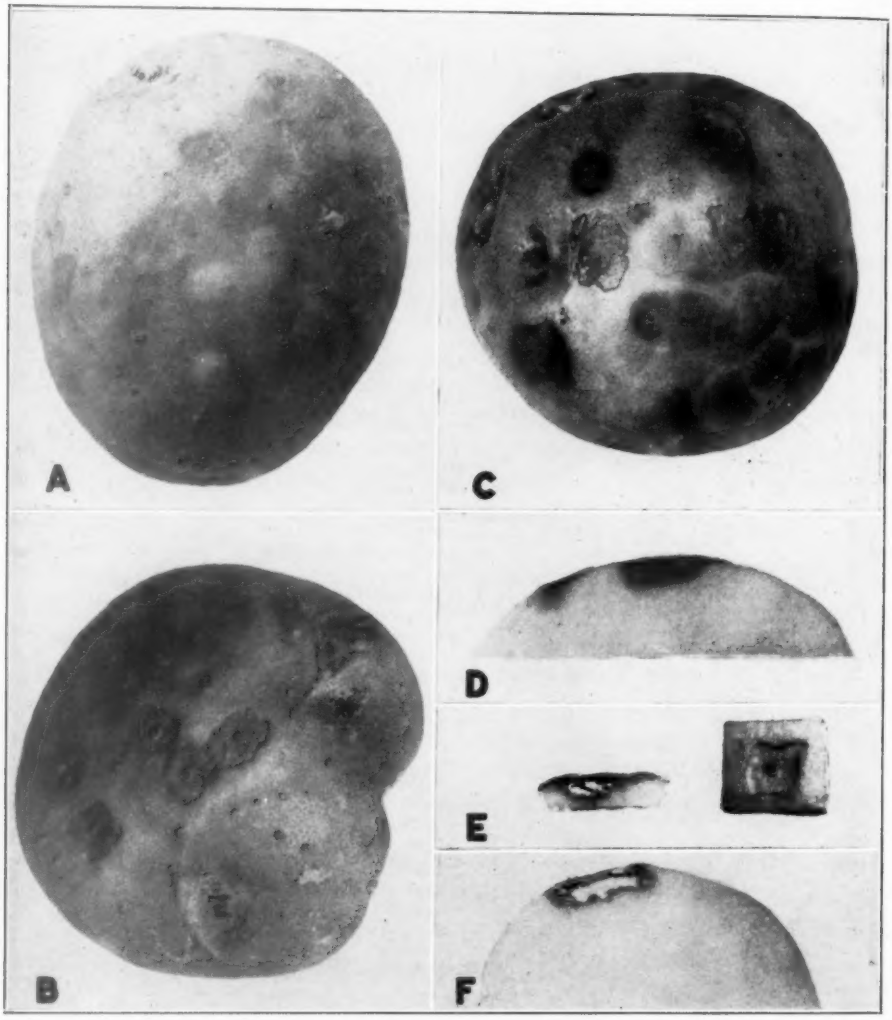

FIG. 2. A. Infected lenticels 24 hr. after artificial inoculation. B. Decay followed by collapse of tissue in infected area; 48 hr. after inoculation. C. Lenticel infection of Bliss Triumph 48 hr. after inoculation. D. Cross section through infected area (from C) to show depth of decay. E. Cross section through artificially inoculated lenticel (at left). Sunken, infected area around lenticel (at right). F. Section through naturally infected lenticel on White Rose. Periderm has become separated from underlying tissue.

organisms. However, evidence of this secondary infection has been observed only rarely in shipments of early potatoes under ordinary transit conditions.

Smith (19) was one of the first investigators to recognize the lenticels of the potato as avenues of infection for bacterial organisms. He reported first observing bacterial lenticel infection of potatoes in 1886. Later, using *Bacillus melanogenes* Pethybr. and Murphy (which he stated was a mixture of *Bacillus phytophthorus* Appel and *Bacillus solanisaprus* Harrison) he obtained typical infection of tubers by way of the lenticels. Leach (9) has considered *B. phytophthorus* and *B. solanisaprus* to be strains of *Erwinia carotovora*.

In the present studies, an investigation of certain phases of lenticel infection with pure cultures of lenticel isolates seemed desirable. In a preliminary experiment, 10 recently harvested Bliss Triumph potatoes were washed in soap and water, rinsed in distilled water, dipped in 80 per cent alcohol and allowed to dry in the air. An 18-hour-old agar slant culture from series 6 (Table 2) was added to distilled water and 5 of the tubers were immersed in this suspension where they were allowed to remain for 24 hours, after which they were removed and placed in moist chambers where a saturated atmosphere was maintained. The temperature during the incubation period was 78° F. For controls, the remaining 5 tubers were immersed in distilled water for 24 hr. after which they were removed and placed in moist chambers. Infections centering at lenticels were first apparent on some of the tubers 18 hr. after removal from the inoculum and lenticel infections appeared on all of the tubers within 24 hr. The infection was often characterized by dark, brown, watersoaked areas 1 to 3 mm. in diameter around the lenticels (Fig. 2, C). The infected areas were often swollen (Fig. 2, A), but on some tubers the tissues in the infected areas were slightly sunken (Fig. 2, B). When infected lenticels were examined, large numbers of bacteria could be seen in them and the organism was readily reisolated in pure culture. Control tubers showed no evidence of bacterial lenticel invasion during the 24-hr. period.

Another experiment, following the technique described, was conducted with the varieties Cobbler and White Rose and a lenticel isolate from series 12. Of the 12 inoculated tubers, 4 of the Cobbler and 3 of the White Rose bore a number of lenticel infections 18 hr. after inoculation and all of the tubers of both varieties had numerous infected lenticels 24 hr. after inoculation. Control tubers remained free of infection during the course of the experiment.

An experiment using similar inoculation methods was carried on in an attempt to determine the length of immersion time necessary to obtain lenticel infections. Twenty-four recently harvested Bliss Triumph potatoes were washed in distilled water, immersed in 80 per cent alcohol for 1 minute, and allowed to dry in the air. These tubers were divided into 6 lots of 4 each and the first 5 lots were then immersed in a water suspension of bacteria from an 18-hr.-old culture of an isolate from series 16 for 1, 2, 3, 4, and 5 min., respectively. The sixth lot of 4 tubers was immersed for 5 min. in the distilled water that had been used in washing the tubers at the begin-

ning of the experiment. Controls consisted of 6 lots of 4 tubers each which were washed, disinfected, and then immersed in distilled water for the various times mentioned. At the termination of each period the tubers were removed from the inoculum and placed in moist chambers in which the atmosphere was near saturation. The temperature during the experiment was 72° F. Final observations were made after an incubation period of 48 hr. The experiment was repeated after an interval of 2 days with an isolate from series 21. The results appear in table 3.

TABLE 3.—*Relationship of time to infection of potatoes by immersion inoculation with lenticel isolates*

Inoc. time (min.)	Av. no. infected lenticels per tuber[a]	Av. diameter of infected area around lenticels (mm.)
Expt. 1. Isolate from Series 16.		
1	7	4.0
2	9	4.7
3	7	3.9
4	10	6.5[b]
5	7	5.0
5 (wash water)	8	6.8
Controls		
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
5	0	0
Expt. 2. Isolate from Series 21.		
1	3	3.8
2	4	4.1
3	7	4.7
4	11	6.0
5	6	5.4
5 (wash water)	4	5.9[b]
Controls		
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
5	0	0

[a] In each instance 4 tubers had been inoculated.
[b] Infected areas coalesced.

Lenticel infections were obtained on tubers immersed in the inoculum for 1, 2, 3, 4, and 5 min., respectively. In these experiments the average number of infected lenticels was as large (or larger) when tubers were immersed in the inoculum for 1 and for 2 min. as when they were immersed for 5 min., thus indicating that prolonging the immersion time had little effect on the number of infections.

In commercial washing practice, tubers often remain in the wash water from 1 to 2 min. This water may be expected to contain large numbers

of bacteria, some pathogenic to potato. If tubers have not already become contaminated with bacterial organisms, there will be ample opportunity for this to occur in the washing process. Frequent changing of wash water or the use of fresh water sprays has been recommended as an aid in cutting down the bacterial content of the wash water. In this connection, however, it is of interest to note the results obtained when tubers were immersed in wash water (Table 3). These tubers had been washed after digging and were washed again in distilled water at the beginning of the experiment. Nevertheless, when they were immersed in this second wash water for 5 min. they showed numerous lenticel infections 48 hr. after removal from the water. These results show that commercially washed potatoes may carry on their surfaces sufficient numbers of virulent soft-rot bacteria to later bring about lenticel infections if favorable environmental conditions are provided.

It has been shown in these studies that lenticel infections are readily obtained by placing uninjured tubers, inoculated by immersion in a water suspension of certain of the lenticel isolates, in moist chambers in which a high relative humidity is maintained. Since, however, no accurate data were available as to the effect of varying relative humidities and temperatures on the incidence of lenticel infection, it seemed desirable to make such determinations.

For this purpose, solutions of sulphuric acid and distilled water were prepared according to the table given by Stevens (21) for providing relative humidities of 70.4, 80.5, 90.0, 94.8, 98.2, and 100 per cent. Two lots each of White Rose and Bliss Triumph potatoes that had been previously stored at 61° and 72° F., respectively, for 24 hr. were used. Immediately upon removal from storage they were washed in tap water, dipped in 80 per cent alcohol, and dried in the air. Six tubers of each of these varieties were inoculated by immersing them for 5 min. in a water suspension of bacteria from an 18-hr.-old agar slant culture of an isolate from series 15, after which they were placed in moist chambers in which the various relative humidities were maintained. Unless otherwise indicated, controls consisted of an equal number of both varieties that had been immersed in distilled water for 5 min. before placing them in moist chambers. All of the inoculated and non-inoculated tubers were then placed in an environment where constant temperatures of 61° and 72° F. were maintained. The results of the experiment appear in table 4.

Lenticel infection did not occur within 72 hours at 61° and 72° F. at relative humidities of 70.4, 80.5, and 90.0 per cent. At a relative humidity of 94.8 per cent no infection occurred when the temperature was 61° F., but infection was visible after 48 hr. incubation when the temperature was 72° F. At a relative humidity of 98.2 per cent and a temperature of 61° F. both varieties showed some infection after 48 hr. At 100 per cent relative humidity and a temperature of 72° F. all of the Bliss Triumph and 50 per cent of the White Rose tubers were infected after 24 hr. incubation. None of the

control tubers at the various relative humidities and temperatures showed lenticel infection at the end of 72 hr. incubation. Infection of tubers did not develop so rapidly at 61° F. as when they were incubated at 72° F., even though relative humidities of 98.2 and 100 per cent were maintained.

The effect of still higher temperatures on the progress of infection was observed in some preliminary experiments when inoculated tubers were incubated at 80° F. and at a relative humidity of approximately 100 per cent. Under these conditions lenticel infection was often visible after 18 hr. incu-

TABLE 4.—*Influence of relative humidity and temperature on lenticel infection of potatoes by a lenticel isolate (from series 15)*

Variety	No. tubers inoculated[a]	Temperature (°F.)	Relative humidity (%)	No. tubers infected[b] after		
				24 hr.	48 hr.	72 hr.
Bliss Triumph	4	61	70.4	0	0	0
	4	72	Do	0	0	0
White Rose	4	61	Do	0	0	0
	4	72	Do	0	0	0
Bliss Triumph	4	61	80.5	0	0	0
	4	72	Do	0	0	0
White Rose	4	61	Do	0	0	0
	4	72	Do	0	0	0
Bliss Triumph	6	61	90.0	0	0	0
	6	72	Do	0	0	0
White Rose	6	61	Do	0	0	0
	6	72	Do	0	0	0
Bliss Triumph	6	61	94.8	0	0	0
	6	72	Do	0	3	4
White Rose	6	61	Do	0	0	0
	6	72	Do	0	1	2
Bliss Triumph	6	61	98.2	0	2	4
	6	72	Do	3	5	6
White Rose	6	61	Do	0	1	3
	6	72	Do	1	3	5
Bliss Triumph	6	61	100.0	0	3	5
	6	72	Do	6	6	6
White Rose	6	61	Do	0	2	3
	6	72	Do	3	4	5

[a] Tubers were inoculated by immersing them in a water suspension of bacteria for 5 min. In each lot an equivalent number of control tubers were immersed in distilled water for 5 min.

[b] None of the 128 control tubers of the two varieties had lenticel infections during 72 hr. incubation.

bation and after 24 hr. a high percentage of the lenticels on the tubers showed infection.

From these data on inoculation tests, under controlled temperature and humidity conditions, it would appear that few or no infections through lenticels will occur in the field or in transit within 3 days at a temperature below 72° F. and a relative humidity less than 94.8 per cent. Under moist or wet soil conditions, however, the above temperature and humidity conditions are frequently exceeded in some regions growing early potatoes, so that

time lag is not of practical importance in the occurrence of infection. Tubers not infected at loading time are not likely to become infected and develop decay during transit unless both the temperature and humidity are high. In commercial as well as in test shipments of nonrefrigerated cars it has been observed that most serious bacterial soft rot occurs at the quarter-length position which is the warmest and probably the most humid part of the load (14).

HISTOLOGICAL STUDIES

Histological studies were made of normal lenticels and those which were naturally or artificially inoculated. For this purpose, small portions of the desired tissue were removed from the tubers and were killed and fixed in a mixture of formalin-acetic acid-alcohol, embedded, and sectioned in the usual manner. Microtome sections 12 microns thick were stained with basic fuchsin with orange G as a counterstain.

Sections were prepared from naturally infected lenticels on tubers that had remained in an atmosphere of low relative humidity for seven days. As a result, the diseased area had lost its turgidity and the tissue surrounding the lenticels had become slightly sunken. A cross section through such a lenticel reveals several layers of periderm cells that have become separated from the parenchyma, resulting in the formation of a cavity or pocket, with suberized parenchyma cells below. Bacteria are found between the cells in this area (Fig. 3, A). A cross section through a naturally infected lenticel having a more advanced stage of decay is shown in figure 3, B. The periderm layer is sunken while the parenchyma cells beneath have become separated from it. Bacterial invasion has become extensive in the parenchyma. Suberized cells may be observed in the invaded area, while immediately beneath it new periderm has been laid down. Artschwager (1) has shown, in studies with potato, that suberization is prerequisite to wound-periderm formation. In the present studies of naturally infected lenticels, suberization invariably preceded wound-periderm formation.

In the preliminary studies of naturally infected lenticels difficulty was experienced in obtaining infected material that would reveal, upon cutting, early stages of bacterial infection. Studies were therefore made of material from artificially inoculated tubers. Sound potatoes were placed in a water suspension of one of the lenticel isolates for 5 hr., after which they were removed and placed in moist chambers. Infections, as indicated by swollen areas around lenticels, were apparent after 24 hr. (Fig. 2, A). Small portions of tissue containing the infected lenticels were removed from the tubers and were killed, fixed, and embedded in paraffin. Infected tissue was also removed from tubers 48 and 60 hr. after inoculation and fixed for further study.

A cross section of a normal lenticel (Fig. 4, A) of the variety Bliss Triumph shows a periderm covered by a thin, rough crust. The periderm is made up of 5 to 8 rows of cells arranged radially. The parenchyma consists of masses of loose, roundish cells.

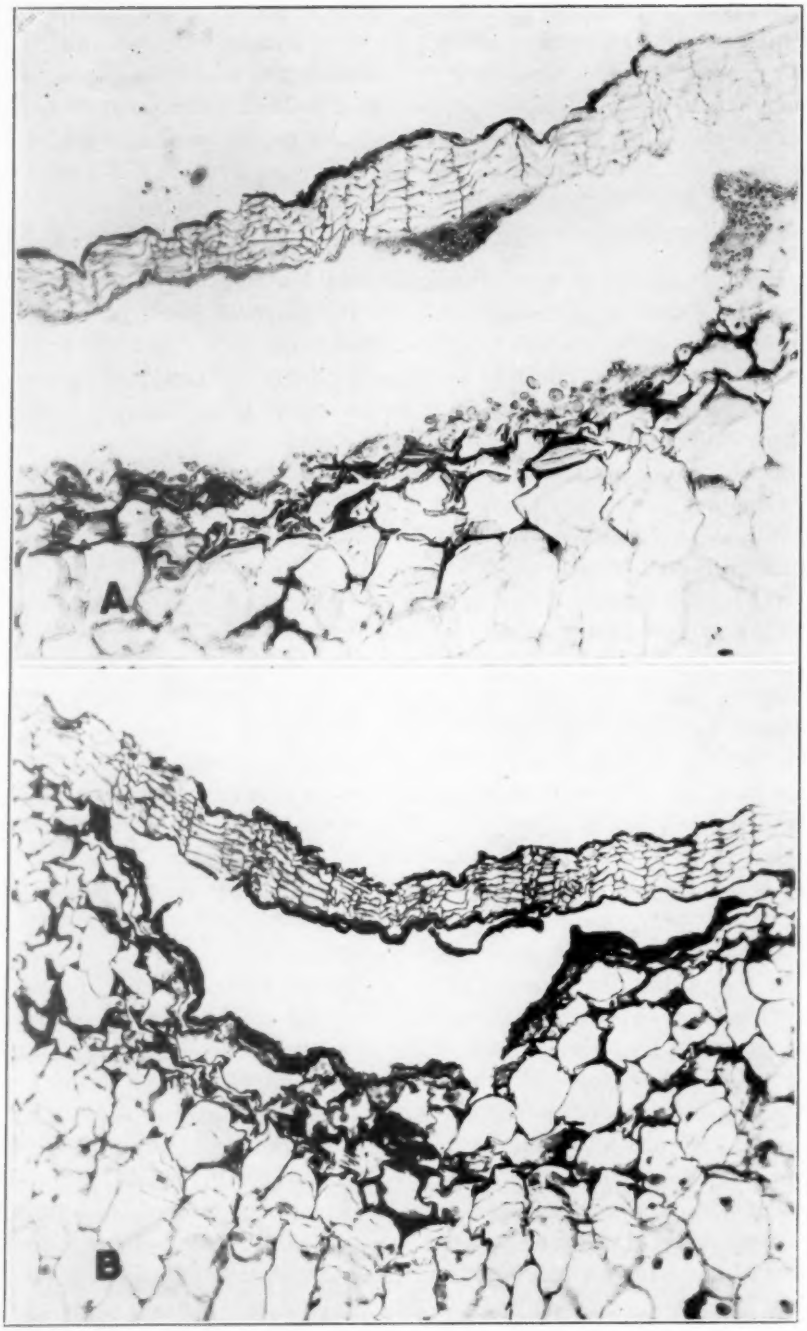

FIG. 3. A. Cross section through naturally infected lenticel. Periderm has become separated from adjoining parenchyma. Suberized cells may be seen beneath. ×125. B. Cross section through naturally infected lenticel in a more advanced stage of decay. Bacterial invasion has become extensive in the parenchyma. Suberized cells may be seen in the invaded area. Immediately beneath new periderm has been laid down. ×125.

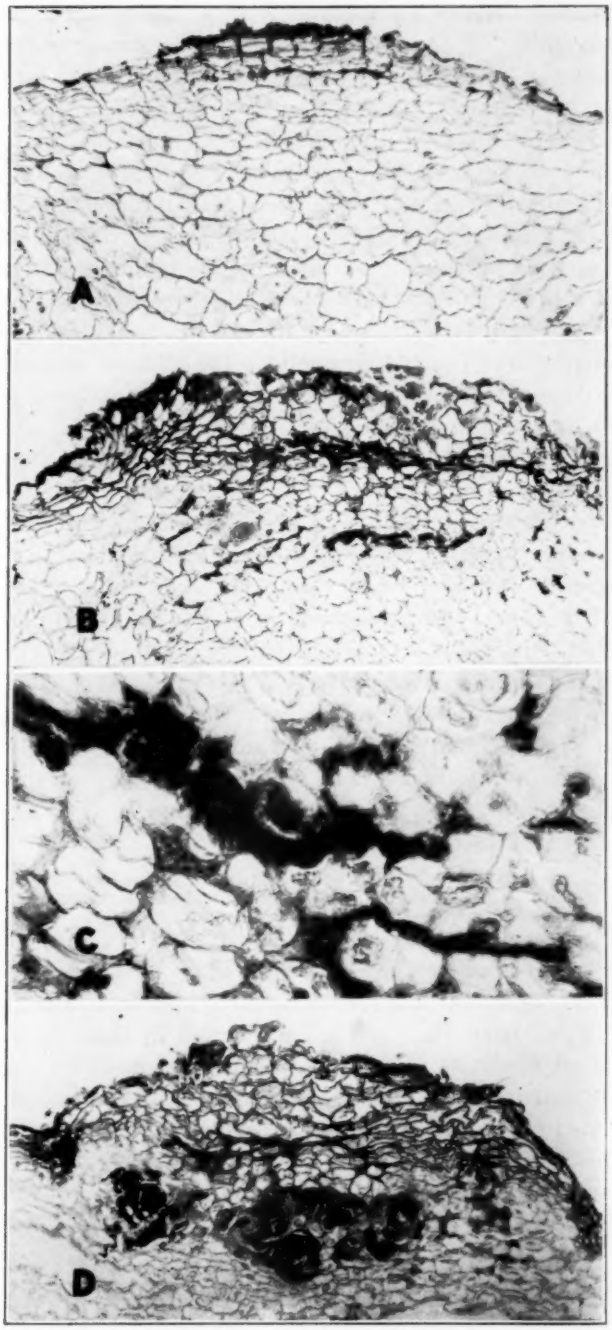

FIG. 4. A. Cross section through normal lenticel. ×135. B. Cross section through infected lenticel 24 hr. after inoculation. ×130. C. Detail of 4, B, more highly magnified to show extent of bacterial invasion between parenchyma cells. ×220. D. Section through infected lenticel 48 hr. after inoculation. Intercellular invasion resulting in some cell collapse has occurred. ×135.

A cross section through an infected lenticel 24 hr. after inoculation is shown in figure 4, B, C. At this stage the bacteria have penetrated to a considerable depth into the lenticel and may be seen between the parenchyma cells. A section through an infected lenticel 48 hr. after artificial inoculation reveals bacterial invasion between cells. Numerous cells have become so disintegrated that masses of bacteria have coalesced along most of the width of the lenticel (Fig. 4, D). Tubers held under high humidity and moderately high temperature, when examined 60 hr. after inoculation, were generally in such a state of disintegration that suitable paraffin sections were not obtained. Free-hand sections, however, revealed that decay had advanced into the tuber often to a depth of 10 to 15 mm., resulting in almost complete destruction of parenchyma cells in the affected area. Under those conditions favoring rapid development of decay no evidence of protective new periderm formation was observed. This indicates that in commercial shipments received on the market with extensive soft rot following lenticel infection, conditions similar to those above may exist.

Tubers were artificially inoculated by immersion in water suspensions of bacteria and after 72 hr. incubation in moist chambers were removed and placed in the open in the laboratory for 72 hr. Sections through infected lenticels on these tubers show essentially the same condition noted with naturally infected lenticels, *viz.*, a slight sunken area in the vicinity of the lenticel, with the separation of the parenchyma from the original periderm layer in the decayed area. Macroscopically, the decayed portion appears to be rather sharply delimited from the normal tissue (Fig. 2, E). Free-hand sections of tissues in this area, stained with ammoniacal gentian violet, reveal a definite suberized layer between the diseased and healthy tissues and the formation of new periderm beneath.

MORPHOLOGICAL AND PHYSIOLOGICAL CHARACTERISTICS OF THE ISOLATES

In these studies the organisms were isolated in pure culture by the dilution plate method. Cultures were maintained on potato-dextrose agar (pH 6.8) and in nutrient broth (pH 6.8). Single-colony isolations from cultures purified by the dilution-plate method were used in these as well as in the pathogenicity studies. All tests were run in duplicate.

Authentic cultures of *Erwinia carotovora* used for comparison in the studies included one from J. G. Leach designated W.Va. 2 in this paper; one from G. W. Keitt (Wis. 1); one from D. H. Rose (U.S.D.A. 3545); and three that the writers had isolated and proved pathogenic. Of the latter, two (3319 and 3470) were originally isolated from potatoes. One, designated S 27, was isolated from decayed spinach.

In the morphological, biochemical, and physiological studies of the various isolates, certain of the recommendations of the Committee on Bacteriological Technique, Society of American Bacteriologists, as given in the Manual of Methods of Pure Culture Study of Bacteria (20), were followed. The results of these studies are summarized in table 5.

Morphological characteristics. For determination of form and size, negative preparations from smears were made with 1 per cent nigrosine. Fisher and Conn's flagella stain (7) was used to determine the number and

TABLE 5.—*Morphological and physiological characteristics of bacteria used in pathogenicity studies*

Isolation series no.	No. isolates used	Nitrates			Gelatin liquefaction	Hydrogen sulphide	Diastatic action	Indole	Milk			Carbohydrates								
												Dextrose			Sucrose			Lactose		
		Chains[b]	Reduction	Gas					Curd	Peptonization	Gas	Acid	Alkaline	Gas	Acid	Alkaline	Gas	Acid	Alkaline	Gas
1	12	+	+	–	–	–	–	–	+	–	–	+		–	+		–	+		–
2	3	+	+	–	–	–	–	+	+	–	–	+		–	+		–	+		–
3	3	+	+	–	–	–	–	+	+	–	–	+		–	+		–	+		–
4	12		+	–	–	–	–	–	+	–	–	+			+		–	+		–
5	3		+	–	–	–	–	–	+	–	–	+			+		–	+		–
6	12	+	+	–	–	–	–	+	+	–	–	+		+	+		–	+		–
7	12	+	+	–	–	–	–	–	–	–	–	+			+		–	+		–
8	12	+	+	–	–	+	–	–	–	–	–	+			+		–	+		–
9	3	+	+	–	–	–	–	–	–	–	–	+			+		–	+		–
10	4		+	–	–	–	–	–	+	–	–	+			+		–	+		–
11	12		+	–	–	–	–	–	+	–	–	+			+		–	+		–
12	1		+	–	–	–	–	–	–	–	–	+			+		–	+		–
13	12	+	+	–	–	–	–	–	–	–	–	+		+	+		–	+		–
14	12		+	–	–	–	–	–	+	–	–	+			+		–	–		–
15	12	+	+	–	–	–	–	+	+	–	–	+			+		–	–		–
16	1		+	–	–	–	–	–	–	–	–	+			+		–	+		–
17	1	+	+	–	–	–	–	–	–	–	–	+			+		–	+		–
18	4		+	–	–	+	–	–	+	–	–	+			+		–	+		–
19	12		+	–	–	–	–	–	+	–	–	+			+		–	–		–
20[a]	12		–	–	–	+	+	+	–	–	–	+			+	–	–	+		–
21	12		+	–	–	–	–	–	–	–	–	+		+	+		–	+		–
22	3		+	–	–	–	–	–	–	–	–	+			+		–	+		–
23	12	+	+	–	–	–	–	–	–	–	–	+			+		–	+		–
24	4	+	+	–	–	+	–	–	+	–	–	+		+	+		–	+		–
25	12		+	–	–	–	–	–	–	–	–	+			+		–	+		–
26	12		+	–	–	–	–	–	–	–	–	+			+		–	+		–
27	1		+	–	–	–	–	–	+	–	–	+			+		–	+		–
28	12	+	+	–	–	–	–	–	–	–	–	+			+		–	+		–
29	12		+	–	–	–	–	–	–	–	–	+			+		–	+		–
30	1		+	–	–	–	–	–	+	–	–	+		+	+		–	+		–
W. Va. 25	1		+	–	–	–	–	–	+	–	–	+			+		–	+		–
Wis. 1	1		+	–	–	–	–	–	+	–	–	+		+	+		–	+		–
3545	1		+	–	–	–	–	–	–	–	–	+		+	+		–	+		–
3319	1		+	–	–	–	–	–	–	–	–	+			+		–	+		–
3470	1		+	–	–	–	–	–	–	–	–	+		+	+		–	+		–
8–27	1		+	–	–	–	–	+	–	–	–	+			+		–	+		–

[a] *Bacterium coadunatum.*

[b] In other morphological characters all isolates were motile, all were Gram-negative, and all were without capsules.

position of flagella. Gram reaction was determined according to Hucker and Conn's (8) modification of Gram's stain. Measurements of bacteria from the different series showed a variation in length from 1.5 to 4.0 μ and in width from 0.5 to 0.8 μ. Neither spores nor capsules were formed. Cells were mostly single or in pairs though an occasional chain was observed.

Biochemical characteristics. In the miscellaneous biochemical reactions the isolates were facultative anaerobes. In the tests on nitrate reduction, 7- and 10-day-old cultures were used. The alpha-naphthylamine-sulfanilic acid test was employed. The organism *Escherichia coli* Migula (Castellani and Chalmers) was used as a control. All of the isolates (except *Bacterium coadunatum*) reduced nitrates to nitrites without the production of gas. Liquefaction of gelatin was determined by means of stab cultures on plain gelatin. The cultures all caused a rapid liquefaction of this medium. In the studies of hydrogen sulphide production, strips of sterilized lead-acetate paper were hung over beef-extract broth cultures of the various isolates. Isolates in series 8, 18, 20, and 24 produced a faint blackening of the paper indicating the presence of hydrogen sulphide. None of the remaining isolates gave a positive reaction. *Escherichia coli*, which gave a positive test for hydrogen sulphide, was used as a control organism.

Tests for diastatic action were made according to the Eckford method (6). None of the isolates (except *Bacterium coadunatum*) were able to hydrolyze starch. The isolates were grown in Bacto-tryptophane broth and were tested for indole production. Cultures in series 2, 3, 6, 15, and 20 gave weakly positive tests. None of the other cultures gave positive reactions for indole. When *Escherichia coli* was used as a control organism, a positive test was obtained. In tests with litmus milk all the isolates produced an acid reaction and coagulated the milk. No peptonization occurred.

Carbohydrate fermentation. In the carbohydrate fermentation studies the peptone-free medium described by Ayers, Rupp, and Johnson (2), but with slight modifications as given by the Society of American Bacteriologists, was used (20). The fermenting action of the bacteria was tested in Smith fermentation tubes to which 1 per cent of the respective sugars had been added. Bromcresol purple at a concentration of 0.02 per cent was added as an indicator. In all of the fermentation studies, color change from purple to yellow was considered the indication of fermentation. The final reaction of the various sugars was also determined by the glass-electrode pH meter.

All of the isolates from the various sources formed acid in dextrose, sucrose, and lactose media. It was observed, however, during the course of the experiment that a wide variation in the rate of acid production existed among many of the cultures. As will be noted, *Bacterium coadunatum* formed acid in dextrose and lactose but not in sucrose.

The results of the morphological studies indicate that there are no essential differences in the morphology of the various soft-rot isolates. The studies show that, with the exception of minor variations in the biochemical and physiological reactions of certain of the isolates, the organisms are closely related. It is apparent also that they are closely related to the authentic cultures of *Erwinia carotovora* used. Since the pathogenicity studies have shown that the various soft-rot isolates have produced essentially the same type of decay, it is concluded that they are strains of *Erwinia carotovora*.

SUMMARY

The importance of blemishes and decay of early potato tubers resulting from bacterial infection of lenticels is discussed and the various types of injuries are described and illustrated.

Bacteria were isolated from discolored and decaying lenticels of tubers from the principal regions growing early potatoes. These organisms were compared with each other and with bacteria isolated from soil about tubers and from various types of soft rot following wounds or heat injury (scald) commonly found on market potatoes. The bacteria isolated from lenticels are shown to be similar to the soft-rot organisms and equally pathogenic.

Wound inoculations with bacterial cultures from lenticels resulted in the production of decay under the same conditions that favor soft-rot development by *Erwinia carotovora*.

Lenticel infections were readily obtained in freshly harvested potatoes by immersing them for 1 minute or longer in water suspensions of bacteria isolated from lenticels.

Under controlled temperature and humidity conditions artificial inoculations did not result in decay in lenticels at 61° F. or 72° F. at a relative humidity below 94.8 per cent. At relative humidities of 98.2 per cent or above infection occurred at 61° F. but at 72° F. the decay was more rapid.

Histological studies of naturally and artificially infected lenticels in various stages of decay showed suberized parenchyma cells in the infected area. A new periderm layer, similar to that following mechanical injuries, was formed beneath the infected area under the lesions in which the decay had ceased to develop.

A study of 66 bacterial isolates from lenticels, soil, and various types of soft-rot lesions revealed that the isolates are morphologically alike and show only minor variations in their biochemical and physiological characteristics. The pathogenic isolates studied are considered to be strains of *Erwinia carotovora*.

U. S. DEPARTMENT OF AGRICULTURE

AND

UNIVERSITY OF CHICAGO.

LITERATURE CITED

1. ARTSCHWAGER, ERNST. Wound periderm formation in the potato as affected by temperature and humidity. Jour. Agr. Res. [U.S.] 35: 995–1000. 1927.
2. AYERS, S. H., P. RUPP, and W. T. JOHNSON, JR. A study of the alkali-forming bacteria found in milk. U. S. Dept. Agr. Bul. 782. 1919.
3. BARGER, W. R., G. B. RAMSEY, R. L. PERRY, and J. H. MACGILLIVRAY. Handling and shipping tests with new potatoes from Kern County, California. Calif. Agr. Expt. Sta. Bul. 664. 1942.
4. BERGEY, D. H. Bergey's Manual of determinative bacteriology. Ed. 5, 1032 pp. The Williams & Wilkins Co. Baltimore. 1939.
5. BROOKS, CHARLES, and L. MCCOLLOCH. Stickiness and spotting of shelled green lima beans. U. S. Dept. Agr. Tech. Bul. 625. 1938.
6. ECKFORD, MARTHA O. Thermophilic bacteria in milk. Amer. Jour. Hyg. 7: 201–221. 1927.

7. FISHER, P. J., and JEAN E. CONN. A flagella staining technic for soil bacteria. Stain. Tech. **17**: 117–121. 1942.
8. HUCKER, G. J., and H. J. CONN. Further studies on the methods of Gram staining. N. Y. (Geneva) Agr. Exp. Sta. Tech. Bul. 128. 1927.
9. LEACH, J. G. The identity of the potato blackleg pathogene. Phytopath. **20**: 743–751. 1930.
10. ———. Potato blackleg: The survival of the pathogene in the soil and some factors influencing infection. Phytopath. **20**: 215–228. 1930.
11. NIELSON, L. W. Solar heat in relation to bacterial soft rot of early Irish potatoes. Amer. Potato Jour. **23**: 41–57. 1946.
12. ———, and F. A. TODD. Bacterial soft rot of Irish potatoes as influenced by sublethal temperatures. Amer. Potato Jour. **23**: 73–87. 1946.
13. RAMSEY, G. B. Fruit and vegetable diseases on the Chicago market in 1935. U. S. Dept. Agr. Plant Dis. Reptr. Suppl. **98**: 1–15. 1937.
14. ———, J. M. LUTZ, H. O. WERNER, and A. D. EDGAR. Experiments on shipping washed early potatoes. Nebr. Agr. Exp. Sta. Bul. 364. 1944.
15. ROSE, D. H. Handling and shipping early potatoes. U. S. Dept. Agr. Circ. 744. 1946.
16. ———, and D. F. FISHER. Desiccation effects on skinned potatoes. Amer. Potato Jour. **17**: 287–289. 1940.
17. ———, and H. A. SCHOMER. Relation of heat and desiccation to bacterial soft rot of potatoes. Amer. Potato Jour. **21**: 149–161. 1944.
18. RUEHLE, G. D. Bacterial soft rot of potatoes in southern Florida. Fla. Agr. Exp. Sta. Tech. Bul. 348. 1940.
19. SMITH, ERWIN F. An introduction to bacterial diseases of plants. 688 pp. W. B. Saunders Co. (Philadelphia and London). 1920.
20. SOCIETY OF AMERICAN BACTERIOLOGISTS. Committee on bacteriological technique. Manual of methods for pure culture study of bacteria. Leaflet 2. Preparation of Media. 9th Ed. 1944. Leaflet 4. Staining methods. 9th Ed. 1946. Leaflet 5. Routine tests for the descriptive chart. Morphological and biochemical. 9th Ed. 1944. Leaflet 6. Further biochemical methods. 9th Ed. 1942.
21. STEVENS, N. E. A method for studying the humidity relations of fungi in culture. Phytopath. **6**: 428–432. 1916.

TUBERCULARIA CANKER AND DIEBACK OF SIBERIAN ELM (ULMUS PUMILA L.)

J. C. Carter

(Accepted for publication December 21, 1946)

In August, 1939, branch and trunk cankers were observed on several Siberian elms, 4 to 10 feet tall, in a commercial nursery planting. Black sporodochia of an undescribed species of *Tuberculariа* were present in the diseased bark of all the cankers.

PATHOLOGY

The cankers on branches and trunks appear during April and May. They form as oval to elongate, slightly sunken areas with the long axis lengthwise of the affected tree part (Fig. 1, A). The surface of the diseased bark becomes red-brown and dotted with numerous black sporodochia (Fig. 1, A). The bark becomes brown to black internally as it dies and dries out. Cankers continue to enlarge until mid June, when callus tissue begins to develop at their margins. Cracks may form in the diseased bark, frequently at the border of the canker, as the callus tissue continues to grow over the diseased area (Fig. 1, B). The diseased bark is pushed outward, breaks and shreds, and usually peels off before the diseased area is callused over (Fig. 1, C). All cankers observed failed to enlarge in succeeding years.

The *Tuberculariа* was found developing in the bark of many branches of Siberian elm affected with dieback in both nursery and ornamental plantings. It was also found developing on twigs that were dying from shading in the inner portion of the crowns of Siberian elms.

PATHOGENICITY

For pathological studies pure cultures of the fungus were grown from single spores isolated directly from sporodochia growing on diseased bark. The fungus was grown on sterilized wheat for the inoculation tests. Seven trunk and 18 branch inoculations on 21 trees were made through bark incisions on April 16, 1940.[1] Two types of bark incisions were made. One was an inverted V-shaped incision (Fig. 1, D) made with a sterile scalpel, and the other was a round hole made with a large sterile cork borer (Fig. 1, E). Wheat infested with actively growing *Tuberculariа* was placed in the incisions. Some incisions were covered with parafilm (Fig. 1, F), others with Scotch tape. Sterilized wheat was placed in 5 bark incisions—2 on trunks and 3 on branches—as checks.

Infection developed from 6 of the 7 trunk inoculations and 17 of the 18 branch inoculations. No infection developed from the five check tests. In most cases, bark infection became evident within 10 days and sporodochia

[1] The date of inoculation was mistakenly stated as April 6 in the abstract published in Phytopath. 36: 395. 1946.

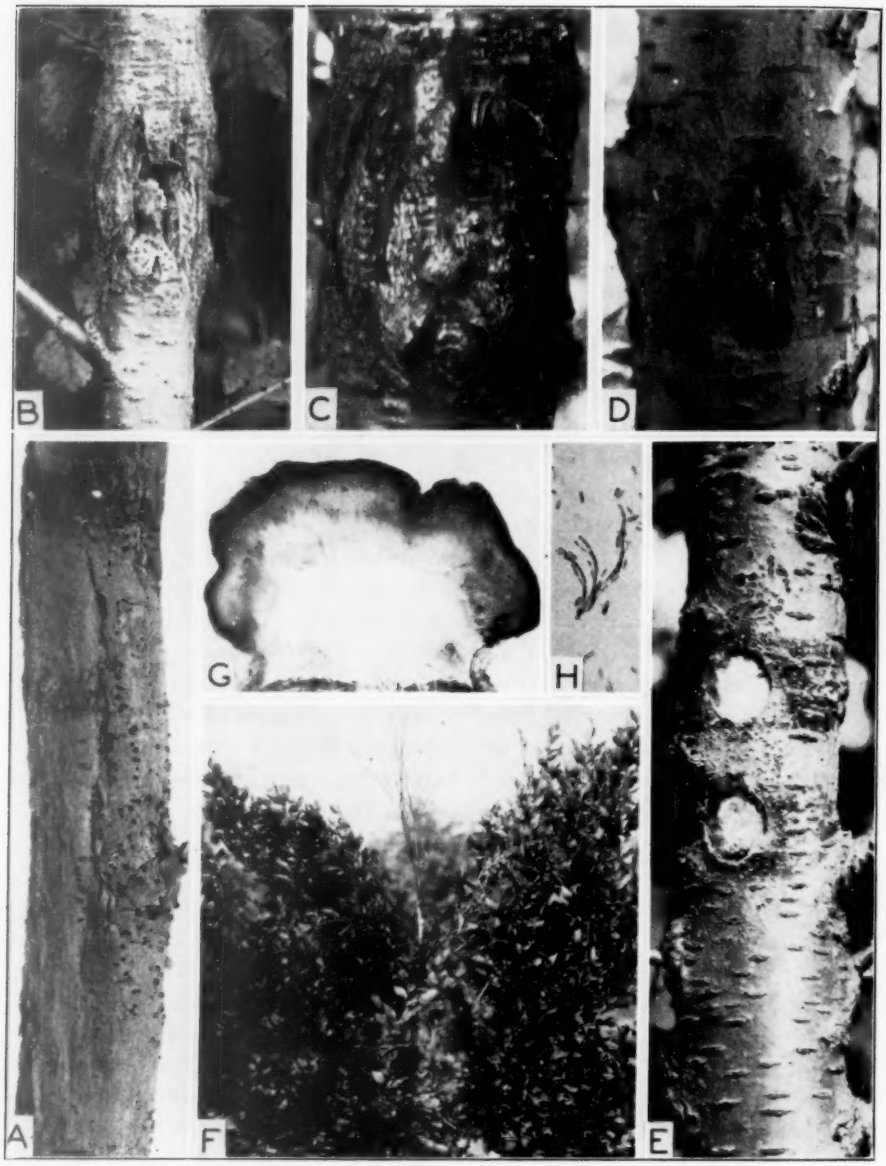

FIG. 1. Tuberculariа canker and dieback of Siberian elm. A. Black, erumpent sporodochia are produced in the diseased bark. B. Trunk canker, produced by artificial inoculation, with black sporodochia on the cracked and peeling diseased bark. C. Same canker as B, callused over after 2 years. D. Trunk canker, produced by artificial inoculation, with young white to cream sporodochia on the infected bark. E. Trunk canker produced by artificial inoculation through holes made with a cork borer. F. Leader killed by infection following artificial inoculation. G. Section of an erumpent sporodochium. H. Conidia are produced aerogenously on hyaline conidiophores.

became visible in about 20 days. First visible evidence of infection was a slight shrinking of the bark around the inoculated region. The infected bark soon became dark gray, then red-brown; and white to cream erumpent sporodochia appeared (Fig. 1, D). The cankers continued to enlarge until mid June when callus tissue began to develop at their margins. Many of the inoculated branches were girdled by the infection and died distal to the inoculated regions within 35 days (Fig. 1, F). Most of the smaller cankers were covered with callus by late August. The larger cankers were not completely covered with callus for one to two years (Fig. 1, C). Cankers produced by both artificial and natural inoculation failed to enlarge in succeeding years.

TAXONOMY

The sporodochia (Fig. 1, G) that develop in the diseased bark are erumpent, pulvinate, scattered to gregarious, smooth, black, horny when dry, and variable in size. They measure up to 1.5 mm. in diameter and 0.9 mm. high. The head is concave beneath and frequently its margins rest on the host, obscuring the short stalk to which it is attached, so that the sporodochium appears to be sessile. Sporodochia produced by artificial inoculation (Fig. 1, D) were white to cream at first but became black and horny within 5 to 6 weeks (Fig. 1, B).

Sporodochia originate in the phellogen-phelloderm region of the stem as compact masses of interwoven hyphae. These masses continue to expand, causing a separation of the phellem and phelloderm. The growing sporodochium ruptures and forces back the overlying phellem which forms a collar around the short sporodochial stalk (Fig. 1, G). Hyphae continue to develop at the base of the sporodochium and are abundant in the underlying cortex and pericycle. Scattered hyphae penetrate through the primary and secondary phloem and reach the cambium but do not invade the xylem. There appears to be little cellular disintegration of the host tissues by the invading hyphae.

Conidiophores produced on the periphery of the sporodochium head are hyaline, irregularly ramose, densely crowded, and straight to strongly curved. They form a compact mass that covers the top of the sporodochium. Groups or bundles of conidiophores appear to branch out from a common base. Each conidiophore has what appear to be short branches, on which the acrogenous conidia are born. These short branches arise immediately beneath septa in the conidiophore (Fig. 1, H). This might indicate that they are not short branches but terminal growth and that the conidiophores continue to elongate by the production of numerous branches. The conidiophores are variable in length.

The conidia (Fig. 1, H) are hyaline, unicellular, ovoid to oblong, and occasionally somewhat allantoid. They are produced acrogenously. When planted on cornmeal agar, they germinated in 24 to 40 hours, each sending out a single germ tube. Many of the germ tubes began to branch within 48 hours. The average linear growth of the germ tubes of 6 spores was 6.1 mm.

per day over a period of 8 days. All isolates produced white colonies consisting of sparsely scattered, interwoven aerial, surface and subsurface hyphae which grow rapidly.

Owens,[2] in 1925, described a Tubercularia canker of *Ulmus pumila* L., which occurred in a nursery planting on the campus of the Oregon Agricultural College. He identified this *Tubercularia* as the imperfect stage of *Nectria cinnabarina* (Tode) Fr. The *Tubercularia* associated with the canker of Siberian elm in Illinois is not the imperfect stage of *N. cinnabarina* (Tode) Fr. It is sufficiently different morphologically from the described species of *Tubercularia* that it is considered a new species.

Tubercularia ulmea n. sp. Sporodochia erumpent, pulvinate, scattered or gregarious, black, horny when dry, up to 1.5 mm. in diameter, up to 0.9 mm. high, inhabiting diseased bark; conidiophores hyaline, irregularly ramose, crowded, straight to strongly curved, 35–87 × 1–3.5 μ, mostly 45–65 × 1.5–2.5 μ; branches short, 4–10 × 1–1.3 μ; conidia acrogenous, hyaline, continuous, ovoid to oblong, occasionally allantoid, 3.8–9.3 × 1.4–3.4 μ, mostly 4.6–6.2 × 1.5–2.3 μ.

Sporodochiis erumpentibus pulvinatis sparsis vel gregariis nigris corneis dummodo sicca usque 1.5 mm. diametris usque 0.9 mm. altis corticem aegrotam incolentibus, conidiophoris hyalinis irregulare ramosis cespitosis rectis usque valde curvatis 35–87 × 1–3.5 μ ut plurimum 45–65 × 1.5–2.5 μ, ramulis brevibus 4–10 × 1–1.3 μ, conidiis acrogenis hyalinis continuis ovoideis usque oblongis interdum allantoideis 3.8–9.3 × 1.4–3.4 μ ut plurimum 4.6–6.2 × 1.5–2.3 μ.

Type specimen: Collected by J. C. Carter, Onarga, Iroquois County, Illinois, August 16, 1939, on branches and trunks of *Ulmus pumila* L., in Illinois Natural History Survey Mycological Collection, Accession Number 29559.

SUMMARY

A canker and dieback disease of Siberian elm develops on trunks, branches, and twigs of affected trees in early spring and black sporodochia of a *Tubercularia* develop in the diseased bark. Smaller cankers are callused over by late summer; large cankers are not callused over for one or two years. Cankers were not observed to enlarge in succeeding years. This *Tubercularia* also attacks and produces black sporodochia on the twigs and small branches which are weakened or killed by shading in the interior of crowns of Siberian elm. Typical cankers and dieback were produced by artificial inoculations. The fungus is described as a new species, *Tubercularia ulmea*.

SECTION OF APPLIED BOTANY AND PLANT PATHOLOGY,
ILLINOIS NATURAL HISTORY SURVEY,
URBANA, ILLINOIS.

[2] Owens, C. E. A Tubercularia canker of Chinese elm. (Abstr.) Phytopath. **15**: 729. 1925.

THE MODE OF VECTOR FEEDING AND THE TISSUES INVOLVED IN THE TRANSMISSION OF PIERCE'S DISEASE VIRUS IN GRAPE AND ALFALFA

BYRON R. HOUSTON,[1] KATHERINE ESAU,[2] AND WM. B. HEWITT[1]

(Accepted for publication January 2, 1947)

INTRODUCTION

It has recently been shown (4) that the two diseases, Pierce's disease of grapes and alfalfa dwarf, are caused by the same virus. Until recently when Severin (5) reported vectors in the family Cercopidae, all of the insects found to be vectors of this virus were confined to the leafhopper sub-family Tettigoniellinae (Cicadellinae) (2, 3). This paper presents the results of a study of the feeding punctures of some of these vectors and the plant tissues involved in the transmission of the virus.

Early observations on the two leafhoppers, *Draeculacephala minerva* Ball and *Neokolla circellata* Baker, showed that they fed for long periods of time and gave off large quantities of excrement without withdrawing the mouth parts from the plant tissues. This behavior indicated that the insects were feeding on some part or parts of the vascular system. A limited number of trials showed that the excrement from a single individual female of *D. minerva* amounted to as much as 2.5 cubic centimeters in a 24-hour period. When adults of *D. minerva* were fed on excised alfalfa stems, after a dilute solution of safranin had been drawn up into the tracheary elements, it was found that some of the dye was taken out by the leafhoppers. (Sections of the stems made after the period of feeding showed the dye present only in the xylem.) The excrement from the leafhoppers was sufficiently colored by the dye to indicate that some of the material taken into their bodies was derived from tracheary elements.

FEEDING PUNCTURES

The feeding punctures of the following insect vectors were studied: adults of *Draeculacephala minerva* Ball, *Helochara sp.*, *Neokolla circellata* Baker, *Carneocephala fulgida* Nott.; nymphs of *D. minerva* and *N. circellata*.

The insects were fed on two hosts of the virus: on grapevine, *Vitis vinifera* (Emperor variety), and on alfalfa, *Medicago sativa* (California common variety). Stems, petioles, and leaf blades were examined for feeding punctures. Furthermore, *Draeculacephala minerva* was fed on healthy and dwarf alfalfa and on healthy and diseased grape. Part of the insects were previously fed on diseased plants, others were free of the virus.

The specimens bearing the feeding punctures were processed following

[1] Assistant Professor of Plant Pathology and Assistant Plant Pathologist in the Experiment Station, University of California, Davis.

[2] Associate Professor of Botany and Associate Botanist in the Experiment Station, University of California, Davis.

an ordinary paraffin method and stained according to the schedule outlined by Esau (1). The material left by the insects in the feeding punctures takes up the stains very readily and makes the punctures very conspicuous in the sections.

All the insects listed, and their nymphs, were found to be seeking the xylem tissue in the process of feeding (Fig. 1, A). The adult insects can reach the xylem in young and old plant organs. The nymphs feed on young plant organs, where the xylem is nearer the surface than in the old. In

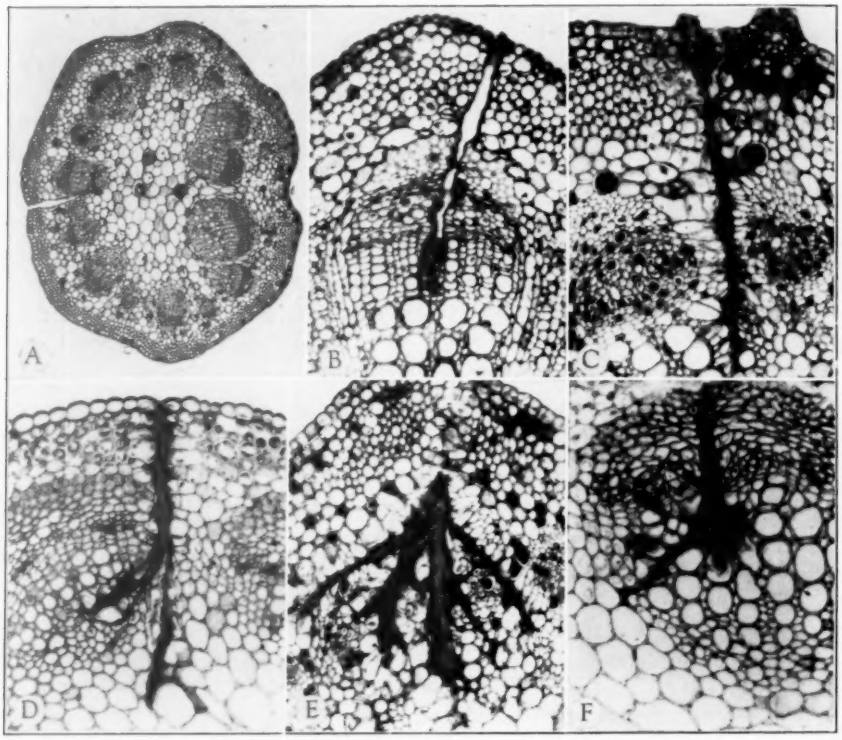

FIG. 1. Feeding punctures of *Dracculacephala minerva* upon grape (A, B, C, and E) and alfalfa (D and F). The section in A was taken from a petiole, the others from stems. The plants used for A and B were diseased, all others were healthy. A illustrates the size of the feeding puncture (to the left in the photograph) in relation to the axis as a whole. The feeding punctures in B and F passed through the phloem in reaching the xylem, those in A, C, and D did not pass through the phloem. The place of entry of the puncture in E is not shown in the photograph; only its inner, much-branched part is visible. F illustrates the penetration of feeding punctures into the lumina of tracheary elements of the xylem. A, × 25; B–F, × 145.

inserting their mouth parts into the plant organs the insects may reach the xylem by cutting in through the phloem (Fig. 1, B); or the puncture may miss the phloem and reach the xylem through the medullary ray (Fig. 1, C and D). Sometimes the insect changes the position of its mouth parts without moving to a new feeding place and leaves a much-branched feeding puncture. Figure 1, E, shows such a puncture and also indicates that the

change in position of mouth parts in this instance might have been induced by the scarcity of water-conducting elements in the region of feeding. The mouth parts of the insects either pass between or through cells. They crush some cells, come in contact with tracheary elements or penetrate into their lumina (Fig. 1, F). In feeding upon leaves, the insects manage to reach the xylem either from the upper or the lower side of the leaf blade.

In punctured stems and leaves of healthy and diseased grapevine and alfalfa, that were collected at different periods after virus-free and virus-carrying adult *Draeculacephala minerva* fed on them (collections were made on the first and up to the seventh day after feeding), 88.2 per cent of a total of 110 punctures ended in the xylem, 2.7 per cent reached the phloem, and 9.1 per cent entered parenchyma only. Of those that reached the xylem, 70.0 per cent passed through the phloem. The presence or absence of virus in the plant or in the insect appeared to have no effect upon the feeding habit of the insect.

To test further, whether or not the presence of the disease in the plant has any effect upon the mode of feeding by the insect, healthy and diseased

TABLE 1.—*The mode of feeding by Draeculacephala minerva upon healthy and diseased grape and alfalfa*

Kind of plant	Total number of punctures	Percentage of punctures		Percentage of punctures that reached xylem	
		Ending in xylem	Not ending in xylem	Through phloem	Not through phloem
Healthy grape	58	82.8	17.2	58.3	41.7
Diseased grape	172	89.0	11.0	69.9	30.1
Healthy alfalfa	159	86.8	13.2	77.5	22.5
Diseased alfalfa	292	93.2	6.8	87.9	12.1

grapevine and alfalfa were subjected to uniform feeding by adult virus-free *Draeculacephala minerva* (25 leafhoppers per terminal part of plant for 4 days). Grapevine petioles and alfalfa stems and petioles were examined. The results are given in table 1 and confirm the information obtained from the first lot of specimens that the majority of punctures reach the xylem and most of these pass through the phloem. The table also shows that the feeding habit of the sharpshooters was similar on diseased and healthy plants of grape and alfalfa. Among the punctures that did not reach the xylem (third data column in table 1) some ended blindly in the cortical, ray, or pith parenchyma and some (about $\frac{1}{2}$ to $\frac{1}{3}$ and fewer) touched the phloem, but very few actually injured this tissue. In other words, most injury to the phloem occurred when the insects punctured this tissue in seeking the xylem.

The phloem of the grape was less frequently injured than that of alfalfa (Table 1). The cause of this is not clear. In both plants fibrous caps occur between the cortex and the functioning phloem in the somewhat older stems (Fig. 1, B and D). The insects appear to penetrate these caps without

difficulty (Fig. 1, B and F) and, on the other hand, they sometimes miss the cap in young stems, in which the fibers are without secondary walls (Fig. 1, C). Perhaps the relative size of the bundles, which are smaller in the alfalfa stem, has something to do with the higher frequency of phloem injury in alfalfa.

TISSUES INVOLVED IN TRANSMISSION OF THE VIRUS

An experiment was conducted to determine the plant tissues in which the virus after introduction by the vector would multiply and induce symptoms of the disease in potted grapevine (Emperor variety) and alfalfa

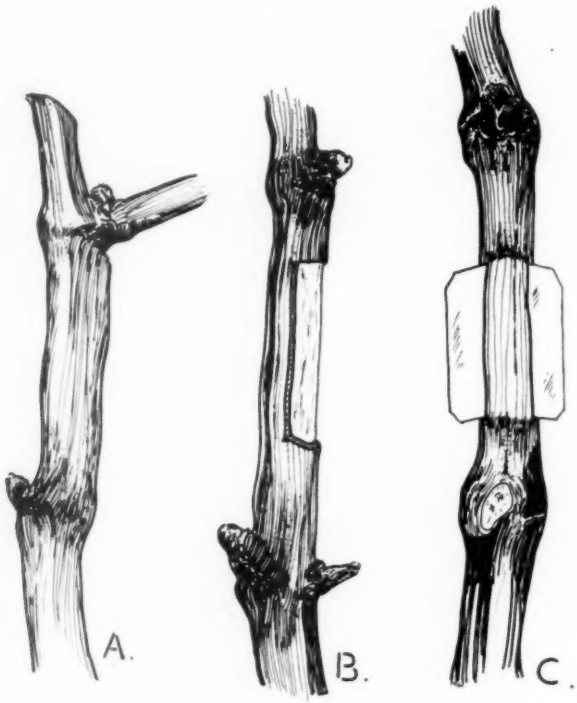

FIG. 2. Parts of grapevine stems illustrating the method of preparing them for feeding viruliferous leafhoppers upon whole stems (A); exposed xylem strip (B); cortex and phloem strip that was lifted from the xylem and separated from the latter by a plate of tin (C).

(California common variety). Viruliferous vectors were fed in the four following ways: on the entire plant including stems and leaves; confined to a three-inch portion of the lower stem; confined to an area of about two square inches of exposed xylem tissue; confined to a portion of the cortex and phloem lifted away from the xylem. The method of preparing stems for this trial is shown in figure 2. The xylem strip was prepared by removing a cortex and phloem section and covering the remainder of the stem with a double layer of tinfoil held in place with grafting wax. The exposed tissues were painted with a thin coating of Dowax[3] to prevent drying. The

[3] Commercial wax emulsion product of Dow Chemical Company.

phloem strip was prepared by making two vertical cuts about one-half inch apart and two inches long and then lifting this section away from the xylem tissue and inserting a piece of tin between the phloem and xylem. Tinfoil was wrapped around the stem above and below the raised section. Small cellophane cages surrounding the feeding area on the stem and cotton plugs at either end were used to confine the leafhoppers to the selected portion of the plant. Ten viruliferous leafhoppers of either of the two species, *Draeculacephala minerva* or *Neokolla circellata*, were confined in the cages for two days. Survival of the vectors was very good on the whole plants, whole stems, and xylem strips, but fell off very rapidly during the second day on the phloem strips. The results of these trials are given in table 2.

Symptoms typical of the respective diseases developed only in those plants in which the vectors could reach the xylem when feeding. The percentage of infection obtained by feeding viruliferous leafhoppers on the

TABLE 2.—*The results of feeding viruliferous vectors on various localized parts of healthy grape and alfalfa plants*

Part of plant exposed to feeding	Kind of plant	No. of plants inoculated	No. of plants diseased
Whole plant	Grape	12	11
Whole plant	Alfalfa	16	12
Whole stem	Grape	25	20
Whole stem	Alfalfa	10	8
Xylem strip	Grape	48	29
Xylem strip	Alfalfa	10	9
Phloem strip	Grape	39	0
Phloem strip[a]	Grape	10	0

[a] The strip of phloem tissue was replaced in contact with the xylem after insect feeding.

following portions of the plant were: whole plant, grape 91.6, alfalfa 75.0; whole stem, grape 80.0, alfalfa 80.0; exposed xylem strip, grape 60.4, alfalfa 90.0; phloem strip kept separated from xylem after feeding, grape 0.0; and the phloem strip replaced in contact with xylem after the feeding, grape 0.0. Three of the 39 phloem strips that were kept separated from the xylem remained alive for eight months. Nine of the 10 phloem strips replaced in contact with the xylem (Table 2) formed a union and remained alive, but the virus did not multiply and pass from this tissue into the remainder of the plant.

As far as the writers are aware this seems to be the first record of a virus appearing to be confined in the xylem and transmitted only when the vectors could reach this tissue in the process of feeding.

MOVEMENT OF THE VIRUS IN ALFALFA STEMS

To determine the rate of movement of the virus in alfalfa stems ten infective leafhoppers of the genus *Draeculacephala* were fed for one-, two-, three-, and four-hour intervals on the basal node and internode of a number of stems. The plants used were of a single clonal line of alfalfa known to be

very susceptible to the disease. The number of stems used in each interval of feeding was 35, 25, 15, and 25, respectively. Immediately following the feeding the stems were severed from the plant about one inch above the basal node—area of feeding—and cut into single node cuttings proceeding from the base of the stem upward. The basal cutting on which the vectors fed was then removed from the plant. All these cuttings were then rooted in sand and transplanted into sterile soil. The number of cuttings from each stem varied from four to seven, depending upon the length of the stem. The nodes were about two and one-half inches apart. Approximately 95 per cent of the cuttings survived.

After eight months the plants grown from the cuttings were examined for symptoms and the results were as given in table 3. The variation in the number of cuttings of the first four nodes was caused by the failure of a few

TABLE 3.—*Upward movement of the virus in alfalfa stems following short intervals of feeding by infective leafhoppers at the base of the stem*

Rooted node and internode from base of stem upward[a]	Number of cuttings[b] from plants upon which infective leafhoppers were fed for the following number of hours:							
	One hour		Two hours		Three hours		Four hours	
	Total	Diseased	Total	Diseased	Total	Diseased	Total	Diseased
First[c]	35	21	24	12	12	7	25	19
Second	35	2	24	1	12	2	22	3
Third	34	0	25	1	15	1	25	0
Fourth	30	0	22	0	13	0	22	1
Fifth	24	1	18	0	6	1	20	1
Sixth	7	0	4	0	2	0	11	0
Seventh	2	0	.....	.....	.....	.....	2	0

[a] The nodes were approximately two and one-half inches apart.
[b] Results were taken 8 months after the cuttings were made.
[c] The leafhoppers fed on this node and internode.

of these to root successfully. The decreasing numbers of cuttings shown for the fifth, sixth, and seventh nodes resulted from differences in the length of stems used and the failure of a few to root. It will be seen from table 3 that the cuttings made from the area of the stem on which the leafhoppers fed—the basal or first node and internode—showed a similar percentage of infection regardless of the feeding interval. The percentage of disease in these cuttings for the one-, two-, three-, and four-hour feeding intervals was 60, 50, 58, and 76, respectively. Thus, the virus survived in an average of only 61 per cent of the cuttings into which it was directly introduced. This result was somewhat similar to that of another trial in which cuttings were made from stems of diseased plants belonging to the same clonal line as those used in the experiment on virus movement. Of the 200 cuttings made four months after the plants expressed symptoms of the disease 144 or 72 per cent of them developed the disease. The virus either failed to survive in some of the cuttings or was present not in all portions of the stems.

Table 3 shows that the number and distribution of cuttings which developed the disease were about the same for all insect feeding intervals. The

data fail to show any difference in the extent of the upward movement of the virus during the different feeding intervals. In the one-hour feeding trial two of the second-node and one of the fifth-node cuttings were diseased. It appears that the virus moved upward a distance of over an inch and was present in the second node and internode within an hour after the vectors began to feed. The fact that one of the fifth-node cuttings developed the disease indicates that in this stem the virus had moved upward a distance of approximately 10 inches in an hour.

These observations suggest a rapid rate of upward movement of the virus in stems, and earlier in this paper it was shown that the vectors fed heavily upon tracheary contents and that the virus was readily transmitted to the xylem. All these observations indicate that the movement of the virus upward in a stem may be associated with the movement of water in the xylem.

SUMMARY

Studies were made on the mode of vector feeding and the tissues involved in the transmission of the Pierce's-disease virus in grape and alfalfa. Feeding punctures of the following insects were studied: adults of *Draeculacephala minerva* Ball, *Helochara sp.*, *Neokolla circellata* Baker, *Carneocephala fulgida* Nott.; nymphs of *D. minerva* and *N. circellata*. All of these insects were found to be seeking the xylem tissue in the process of feeding. In a representative lot of material using *D. minerva*, 88.2 per cent of a total of 110 punctures ended in the xylem, 2.7 per cent reached the phloem, and 9.1 per cent entered parenchyma only. Penetration of the mouth parts to reach the xylem appeared to be made at random through the phloem or medullary ray. The mouth parts either passed between or through cells including tracheary elements. The presence or absence of the virus either in the vectors or in the host plant had no effect upon their mode of feeding. The feeding of viruliferous vectors on different parts of grape and alfalfa stems showed that the virus could multiply and cause the disease only when xylem tissue could be reached by the vector during the feeding process. The rapid upward movement of the virus in alfalfa stems points to the possibility that the virus may move in the tracheary elements.

THE DIVISIONS OF PLANT PATHOLOGY AND BOTANY,
UNIVERSITY OF CALIFORNIA,
DAVIS, CALIFORNIA.

LITERATURE CITED

1. ESAU, KATHERINE. Anatomical and cytological studies on beet mosaic. Jour. Agr. Res. [U.S.] **69**: 95–117. 1944.
2. FRAZIER, NORMAN W. Phylogenetic relationship of the nine known leafhopper vectors of Pierce's disease of grape. (Abstr.) Phytopath. **34**: 1000. 1944.
3. ————, and J. H. FREITAG. Ten additional vectors of the virus causing Pierce's disease of grapes. Phytopath. **36**: 634–637. 1946.
4. HEWITT, WM. B., BYRON R. HOUSTON, NORMAN W. FRAZIER, and J. H. FREITAG. Leafhopper transmission of the virus causing Pierce's disease of grape and dwarf of alfalfa. Phytopath. **36**: 117–128. 1946.
5. SEVERIN, HENRY H. P. Transmission of virus of Pierce's-grapevine disease and alfalfa dwarf by spittle insects, the first reported vectors in Cercopidae. (Abstr.) Phytopath. In press.

BOOK REVIEWS

GARRETT, S. D. *Root Disease Fungi.* 177 pp. 9 figs. Published by Chronica Botanica Co., Waltham, Mass. (New York City, G. E. Stechert and Co.) 1944. $4.50.

A real need for a thorough review and discussion of accumulated knowledge concerning root disease fungi has recently been satisfied by S. D. Garrett of the Rothamsted Experimental Station, England, in his book under the above title. This comprises an authoritative account of the behavior of these microorganisms in the soil and of their parasitic activities in the roots of plants, as influenced by environmental factors. It includes as well several chapters on control measures based largely on principles outlined. The treatise is the first of its kind in book form. It represents a refreshing approach to the treatment of soil-borne pathogenic fungi in that it deals with them as an ecological group rather than as a collection of more or less remotely related taxonomic entities. The result is a clear and connected exposition of a complex subject. Following an introductory chapter, dealing with the history of soil-borne plant parasitic fungi, their interrelationships with saprophytic microorganisms in the soil and general measures of root disease control, five chapters are devoted to a discussion of the influence of various factors on the parasitic behavior of root disease fungi and two to their saprophytic spread and survival in the soil. Then follow seven chapters dealing with root disease control in field, plantation, and glasshouse crops. A sixteen-page bibliography, a general index and an author index conclude the work. Errors, typographical or otherwise, *e.g.*, "longivity" (page 2 of the contents) and "scelerotia" (page 81) are rare and there are few other detracting features, especially for a first edition. However, exception may possibly be taken to the inclusion of the smut fungi under the title chosen, to the use of the phrase "infected soil" rather than "infested soil" in several places, and to the small amount of attention given to certain control measures, *e.g.*, the use of resistant varieties. These are minor considerations which most readers will agree are greatly overshadowed by the many virtues of the book. We are indebted to the author for bringing together in it a wealth of previously scattered information and for organizing and appraising it on the basis of his own experience. While he has naturally drawn freely on the latter he has also covered a wide range of work done by other people. In this book the author has ploughed new ground in an effective and able manner, and has made a contribution of permanent value to biology and to agriculture. A wide range of readers especially in these fields will find it an invaluable reference.—A. W. HENRY, University of Alberta, Edmonton, Alberta, Canada.

WAKSMAN, SELMAN A. *Microbial Antagonisms and Antibiotic Substances.* The Commonwealth Fund, New York. 350 pp. 34 figures. 48 tables. 1945. Price $3.75.

Dr. Waksman's extensive research in the field of soil microbiology is well known, and this book is a timely contribution to a new, fascinating, and rapidly expanding field of knowledge, and will be welcomed by both specialist and layman. There are slightly over one thousand literature references, and the subject is presented in fourteen chapters. The first three of these outline the rôle of the microbial populations in their natural habitats in reducing animal and plant wastes and the effect of their antibiotic substances on the relative ability of certain groups to survive better than others in mixed populations. In the next four chapters are reviewed the bacteria, actinomycetes, fungi, and microscopic animal forms, respectively, as producers of antibiotic substances, and the effect of these on members of their own and other groups. Perhaps the chapters most interesting are those on the chemical nature and biological properties of various antibiotics and their use in controlling bacterial diseases of man and animals. Penicillin receives merited attention, as well as a number of substances which Waksman and his colleagues have isolated, mostly from the actinomycetes. Phytopathologists will find the chapter on microbiological control of soil-borne diseases of special interest, and a convenient review of related literature. In general the conclusions of each writer are listed without critical comment, which probably is a wise course to follow at this date. A casual review of this literature reveals that phytopathologists were early pioneers in establishing that living bacteria and fungi, and substances produced by them, would definitely prevent the development of certain plant diseases caused by soil-borne and other plant pathogens. The phytopathologists will also agree with Dr. Waksman that under field conditions practical biological control of soil-borne diseases has been rather disappointing when compared with the spectacular progress made with penicillin in combating disease-producing agents in man and animals. The last chapter suggests that a really extensive search of the actinomycetes, bacteria, and fungi for new antibiotic substances of therapeutic value will be richly rewarded.—G. B. SANFORD, Pathologist in Charge, Dominion Laboratory of Plant Pathology (Science Service, Canada Department of Agriculture), University of Alberta, Edmonton.

REPORT OF THE 38TH ANNUAL MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

The American Phytopathological Society held its 38th annual meeting at the Netherland Plaza Hotel in Cincinnati, Ohio, December 28–30, 1946. Two hundred and eighty-six members from forty-one states and three foreign countries registered. One hundred and three papers were accepted by the editorial committee for presentation at the meeting. The sections and number of papers presented in each follow: physiology of fungi and antibiotics, 12; fruit diseases, 4; Dutch elm disease and other papers, 9; virus diseases, 11; field crop diseases, 12; vegetable diseases, 10; fungicides, 2 sections, 18; breeding for resistance, 8; joint meeting with the Potato Association of America, 7; and fungus diseases, 12.

Conferences included "Fungicide Colloquium," "Extension Workers," "Plant Disease Survey," "Upper Mississippi Valley Plant Pathologists," and "Tomato and Potato Late Blight Symposium."

The Phytopathologists' dinner, held in the Hall of Mirrors, Netherland Plaza, on Sunday evening, December 29, was attended by two hundred and thirty-four.

Council for 1947:

A. J. RIKER, President (1 yr.), University of Wisconsin, Madison 6, Wisconsin.
R. S. KIRBY, Vice-President (1 yr.), Pennsylvania State College, State College, Pennsylvania.
E. M. JOHNSON, Secretary (3-yr. term expires 1947), Kentucky Agricultural Experiment Station, Lexington 29, Kentucky.
M. C. RICHARDS, Treasurer, and Business Manager of PHYTOPATHOLOGY (3-yr. term expires 1949), University of New Hampshire, Durham, New Hampshire.
HELEN HART, Editor-in-Chief, PHYTOPATHOLOGY (3-yr. term expires 1948), University Farm, St. Paul 1, Minnesota.
E. E. CLAYTON, Bureau of Plant Industry, Beltsville, Maryland.
J. H. CRAIGIE, Central Experimental Farm, Ottawa, Canada.
MAX W. GARDNER, University of California, Berkeley, California.
J. H. JENSEN, North Carolina State College, Raleigh, North Carolina.
S. G. LEHMAN, North Carolina State College, Raleigh, North Carolina.
THOMAS SPROSTON, JR., University of Vermont, Burlington, Vermont.
C. M. TUCKER, Botany Department, University of Missouri, Columbia, Missouri.

Representatives:

A.A.A.S. Council. J. G. HORSFALL, R. W. GOSS.
Division of Biology and Agriculture, National Research Council. J. C. WALKER.
Board of Editors, American Journal of Botany. A. A. DUNLAP.

Standing Committees:

Donations and Legacies. A. G. NEWHALL, R. E. VAUGHN, G. F. WEBER, S. N. ZELLER, N. J. GIDDINGS, Chm.
Extension. J. O. ANDES, O. D. BURKE, O. C. BOYD, S. B. FENNE, DONALD COE, H. R. GARRISS, R. J. HASKELL, W. J. HENDERSON, T. H. KING, Chm.
Investments. MARVIN E. FOWLER, L. M. HUTCHINS, NEIL E. STEVENS, R. M. CALDWELL, M. C. RICHARDS, Chm.
Necrology. W. J. ZAUMEYER, H. D. BARKER, Chm.
Phytopathological Classics. L. C. KNORR, Editor. JOHN NIEDERHAUSER, Business Manager.
Placement. S. J. P. CHILTON, D. G. FLETCHER, M. W. GARDNER, R. J. HASKELL, L. M. MASSEY, R. S. KIRBY, Chm.
Public Relations. O. D. BURKE, L. S. HITCHNER, J. C. WALKER, H. T. COOK, J. E. LIVINGSTON, J. D. MOORE, F. J. GREANEY, J. H. JENSEN, A. G. NEWHALL, HARRY R. O'BRIEN, K. STARR CHESTER, Chm.
Regulatory Work and Foreign Plant Diseases. C. R. ORTON, R. P. WHITE, E. C. STAKMAN, Chm.
Society Organization. GEORGE ARMSTRONG, F. J. GREANEY, FREEMAN WEISS, J. B. KENDRICK, J. C. WALKER, O. C. BOYD, Chm.
Union of American Biological Societies (and Biological Abstracts). DONALD FOLSOM, L. M. MASSEY, W. C. SNYDER, FREEMAN WEISS, H. P. BARSS, G. C. KENT, Chm.; HELEN HART and E. M. JOHNSON (ex officio).
International Cooperation. H. P. BARSS, G. H. COONS, J. G. HARRAR, OTTO REINKING, J. A. STEVENSON, E. C. STAKMAN, Chm.

Special Committees:

Fungicides. M. B. MOORE, H. W. THURSTON, JR., J. D. WILSON, J. G. HORSFALL, S. E. A. MCCALLAN, Chm.

Subcommittee on Seed Treatments. C. H. ARNDT, K. W. KREITLOW, J. E. MACHACEK, GEORGE SEMENIUK, R. W. LEUKEL, L. D. LEACH, W. B. ALLINGTON, C. M. HAENSELER, E. D. HANSING, M. B. MOORE, Chm.

Subcommittee on Methods. M. C. GOLDSWORTHY, C. S. HOLTON, J. G. HORSFALL, M. B. MOORE, C. F. TAYLOR, J. D. WILSON, S. E. A. MCCALLAN, H. W. THURSTON, JR., Chm.

Subcommittee on Dusts and Sprays. J. M. HAMILTON, H. F. WINTER, W. H. BUCHHOLTZ, A. G. NEWHALL, J. W. HEUBERGER, A. W. DIMOCK, J. D. WILSON, Chm., and advisory members, FRANK IRONS, E. D. WITMAN, S. M. DIETZ, O. C. BOYD, H. P. BARSS, L. G. UTTER.

Subcommittee on Special Problems. J. G. LEACH, L. S. HITCHNER, DWIGHT POWELL, F. L. HOWARD, J. G. HORSFALL, Chm.

Fungus Nomenclature. C. M. TUCKER, D. S. WELCH, ERDMAN WEST, G. L. ZUNDEL, J. A. STEVENSON, Chm.

Nomenclature and Classification of Plant Viruses. C. W. BENNETT, L. M. BLACK, JAMES JOHNSON, H. H. MCKINNEY, H. R. MCCLARTY, FRANK MCWHORTER, R. H. LARSON, FREEMAN WEISS, Chm.

Plant Disease Prevention. K. D. BUTLER, T. H. KING, R. S. KIRBY, E. C. STAKMAN, R. P. WHITE, D. G. FLETCHER, Chm.

Membership Committee. W. F. BUCHHOLTZ, W. C. SNYDER, G. C. KENT, A. A. DUNLAP, H. A. RODENHISER, E. M. JOHNSON, R. W. SAMSON, Chm.

Publication Problems. JOHN NIEDERHAUSER, W. C. SNYDER, A. J. RIKER, Chm.; HELEN HART and M. C. RICHARDS (ex officio).

National Security. M. A. MCCALL, S. B. FRACKER, BERCH HENRY, W. H. WESTON, E. C. STAKMAN, H. T. COOK, H. H. THORNBERRY, Chm.

Temporary Committees for 1946:

Auditing. ERIC G. SHARVELLE, J. R. SHAY, Chm.

Resolutions. R. H. WELLMAN, R. H. LARSON, Chm.

Temporary Committees for 1947:

Sustaining Associates. R. M. CALDWELL, C. H. ARNDT, J. W. HEUBERGER, E. W. BODINE, C. E. SCOTT, A. G NEWHALL, J. J. CHRISTENSEN, Chm.

Publication of Special Material. H. P. BARSS, J. G. LEACH, W. H. TISDALE, DONALD CATION, Chm.

Report of the Secretary. On December 31, 1945, the total membership was 1100. During 1946, 72 new members were added and 64 reinstated, making a total of 1236. Fifty-seven members were suspended for non-payment of dues, 5 died, and 13 resigned. Thus the total membership on November 15, 1946, was 1161.

One hundred and forty-three names, whose applications were received after the St. Louis meeting, March 30, 1946, were elected to membership on December 30, 1946. The total membership on December 30, 1946, was 1304.

Report of the Treasurer. Statement of accounts for the year ending September 30, 1946.

Receipts:

Balance from 1945			$2378.07
Annual dues:			
1945	$ 30.00		
1946	4999.52		
1947	113.00		
1948	4.60	$5147.12	
Excess illustrations		45.09	
Sales		179.60	
Sustaining contributors		300.00	
Total receipts			5671.81
			$8049.88

Expenditures:

Member subscriptions transferred to PHYTOPATHOLOGY		
1945	$ 24.00	
1946	3998.50	
1947	90.40	
1948	3.28	$4116.18

Transferred to PHYTOPATHOLOGY for:		
Sales:		
PHYTOPATHOLOGY	179.60	
Excess illustrations	45.09	224.69
Secretarial work and expenses, Office of Secretary		79.15
do , Office of President		42.38
do , Office of Treasurer		297.50
Printing and stamped envelopes		294.14
Stamps		8.00
Office supplies		1.90
Annual meeting expense		128.05
Expense of Placement Committee		21.05
Expense of Necrology Committee		1.02
Bank charges		10.72
Checks returned		20.00
Exchange charges		2.52
Refund of overpayment of dues		1.00
Miscellaneous		20.00
Total expenditures		$5268.30
Balance on hand September 30, 1946		2781.58
		$8049.88

Report of the Business Manager. The total number of nonmember subscribers on November 30, 1946, was 706, representing a net gain of 152 for the year 1946. These consisted of 317 domestic, 31 Canadian, and 358 foreign subscribers. A total of 93 subscriptions were received from the U.S.S.R. Not included in the reported subscriptions for 1946 are 55 subscriptions for the current volume 36 by the American Library Association, to be held by the Society for eventual shipment to foreign countries as may be designated by that Association.

The sales of back volumes and issues during 1946 totaled $2793.74. Most of these orders were from foreign countries where PHYTOPATHOLOGY could not be sent during the war.

Statement of accounts for the year ending September 30, 1946.

Receipts:			
Balance from 1945			$7318.91
Subscriptions:			
1945	$ 66.60		
1946	4200.25		
1947	295.05		
1948	3.40	$4565.30	
Member subscriptions:			
1945	24.00		
1946	3998.50		
1947	90.40		
1948	3.28	4116.18	
Sales of back numbers of PHYTOPATHOLOGY		2793.74	
Sales of Membership List		3.50	
Advertising:			
1945	377.38		
1946	829.12	1206.50	
30-Year Index		162.70	
Interest on Sinking Fund:			
First mortgage	21.50		
Building and Loan	50.00		
U. S. Bond Series G	25.00	96.50	
Interest on current funds		124.39	
Grant from Rockefeller Institute		600.00	
Allowance on reprints		594.16	
From authors for excess illustrations		184.04	
Total receipts			14,447.01
			$21,765.92

Expenditures:

Printing, distributing, and storing PHYTOPATHOLOGY:				
Vol. 35, no. 9		$676.46		
10		834.74		
11		699.03		
12		859.03		
Vol. 36, no. 1	(less engraving costs)	700.55		
2	do	662.74		
3	do	582.79		
4	do	658.05		
5	do	649.76		
6	do	539.64		
7	do	899.85		
8	do	885.71		
Engravings, February–September		951.44	$9599.79	
Postage, PHYTOPATHOLOGY			565.79	$10,165.58
Secretarial work and office expense, Editor-in-Chief				927.76
do			, Advertising Manager	59.94
Commission for Advertising Manager, 1945				75.50
Secretarial work for Business Manager				349.35
Stamps				4.68
Printing and stamped envelopes				69.52
Office supplies				2.20
Miscellaneous				20.16
Postage, 30-Year Index				4.30
Refund, subscriptions and sales				73.70
Purchase, back volumes				31.80
Bank charge				.62
Total expenditures				$11,785.11
Balance on hand:				
Checking account			4911.65	
Northwestern Federal Savings and Loan (Washington, D. C.)			5069.16	9,980.81
				$21,765.92

Sinking Fund. There was no change in the principle amount of the sinking fund during the past year, the total remaining $9676.00.

First mortgage note, at 4½ per cent interest, deposited with McLachlen Banking Corporation for collection	$ 500.00
U. S. Savings Bond, Series G, No. M1905602G, 2½ per cent	1000.00
Invested with the following:	
Columbia Permanent Building Association (accrued dividends $68.78)	568.78
District Building Loan Association (accrued dividends $202.22)	1702.22
National Permanent Building Association (accrued dividends $308.55)	2308.55
Northwestern Federal Savings and Loan Association (certificate)	2000.00
Perpetual Building Association (accrued dividend $137.56)	1137.56
Prudential Building Association (accrued dividend $32.53)	208.53
Arlington and Fairfax Building and Loan (accrued dividend $45.68)	1045.68
	$10471.32
Less interest due PHYTOPATHOLOGY	795.32
	$ 9676.00

The Lyman Memorial Fund, obtained from voluntary contributions, now totals $3310.82. This amount is invested with the Brookland Building and Loan Association at 2½ per cent. The account for 1946 is as follows:

Balance on hand, October 1, 1945	$ 3499.36
Dividends, December 31, 1945, and June 30, 1946	89.44
Voluntary contributions	115.00
	$ 3703.80
Less interest due PHYTOPATHOLOGY	392.98
	$ 3310.82

Additional Endowment:

War Savings Bond, Series F	
Total, September 30, 1945	$ 1100.00
Contributed October 1, 1945–September 30, 1946	25.00
War Savings Stamps	
Total, September 30, 1946	7.00
	$ 1132.00

The 30-Year Index. Summary of receipts and expenditures (funds deposited in PHYTOPATHOLOGY checking account) October 1, 1945, to September 30, 1946:

Balance (receipts less costs) September 30, 1945	$ 215.12
Receipts October 1, 1945, to September 30, 1946	162.70
	$ 377.82
Expenses October 1, 1945, to September 30, 1946	4.30
Balance (receipts less costs) September 30, 1946	$ 373.52

Membership List Account, 1945–1946.

Balance on hand, October 1, 1945	$ 49.96
Membership lists sold	2.50
Balance on hand, September 30, 1946	$ 52.46

Report of the Auditing Committee, as of September 30, 1946. We have examined the books of the Treasurer of The American Phytopathological Society and of the Business Manager of PHYTOPATHOLOGY for the period October 1, 1945, to September 30, 1946. We found all receipts and expenditures and all funds of the Society and of PHYTOPATHOLOGY lucidly and accurately recorded. Miss Melba K. House is to be highly commended for her excellent performance in maintaining these records.

Signed: J. R. SHAY, *Chairman*
E. G. SHARVELLE

C. P. A. Report on books of Treasurer and Business Manager for October 1, 1946, to January 21, 1947. Pursuant to the request of Dr. Ralph M. Caldwell, I have examined the records pertaining to cash receipts and disbursements of The American Phytopathological Society and PHYTOPATHOLOGY, of which he is Treasurer and Business Manager, respectively, for the period from October 1, 1946, to January 21, 1947.

Verification of cash receipts extended only to substantiating that all receipts which were entered in the cash books were deposited in the designated depository. All cash disbursements were substantiated by receipted vouchers. The cash balances at the end of the period were verified by confirmations received from the respective depositories. Assets of The American Phytopathological Society set aside for specific purposes consisting of government securities and deposits in building and loan associations were also verified.

Based on the above examination, in my opinion, the statements of The American Phytopathological Society and PHYTOPATHOLOGY correctly set forth the receipts and disbursements for the period reviewed.

February 10, 1947

C. D. D'AOUST
Certified Public Accountant
Lafayette, Indiana

Report of the Advertising Manager. PHYTOPATHOLOGY carried a total of 108 paid advertisements during the year 1946. There were 63 full-page, 33 half-page, and 12 quarter-page advertisements.

The gross income from advertising was $1,421.50. The net income to the Society will appear in the Treasurer's report. Advertising agencies are allowed a 15 per cent commission and a 2 per cent discount is permitted when bills are paid within 10 days. This accounts for the difference between gross and net income.

In addition to paid advertisements, the Journal has carried some announcements and notices for the Society in the advertising section.

Report of the Editor-in-Chief. The 1059 pages of volume 36 of PHYTOPATHOLOGY were used by 278 authors in the publication of 89 long articles, 37 phytopathological notes, 122 abstracts, 7 biographical sketches, and 1 book review. Three reports and three announcements were published for The American Phytopathological Society. The

volume contained 7 portraits and 221 illustrations for scientific articles and notes. Of the 207 tables in the volume, 190 each required less than a full page, 12 required full pages, and 5 required from one and one-half to 7 pages each. The November issue contained the manual "Preparation of manuscripts for PHYTOPATHOLOGY," written by Dr. A. J. Riker and authorized by the Society at its annual meeting in December, 1944.

On December 1, 1946, there were 50 papers on hand: 23 had been accepted for publication and 15 of these were in press; 16 were being revised by the authors; and 11 were under consideration by the editors. Between March 1 and December 1, 1946, 12 papers were withdrawn or rejected.

The time between submittal of a paper and its acceptance varies from 6 weeks to 10 months, depending on the clarity of the paper, the criticisms of the reviewers, and the advisability of revision. The time between acceptance of a manuscript and its appearance in the Journal varies from 4 to 6 months. From 1 to 2 months are required for marking copy and for printer's composition work; approximately 1 month is needed for correction of galley proofs and submittal to authors; and approximately 2 months elapse between placement in a monthly number of the Journal and the issuance of the number.

Again we are indebted to the Rockefeller Institute for financial support of the journal.

It is a pleasure to acknowledge the editorial and clerical assistance of Frances Cooper, the work of J. M. Daly in preparation of the index and in proof-reading, and the excellent cooperation of editors and associate editors.

The editors have contributed considerable time and effort in reviewing manuscripts, and they have attempted to judge each manuscript on its merits and its present and future value. Judgment has been difficult at times because several manuscripts have dealt with scientific research in fields bordering on plant pathology.

Report of Representative in the Division of Biology and Agriculture, National Research Council, for 1946. Since our annual meeting in March 1946, several matters of importance to the Society have come before the Division:

(1) The proposal for an Institute of Biologists to represent Biology as a whole in National Affairs was presented by D. W. Bronk (now Secretary of the National Research Council). An informal gathering of representatives of various societies to discuss further action was suggested. H. P. Barss, our representative of the Union of Biological Societies, was asked to represent us, and J. G. Leach was asked to serve as alternate. Progress to date has been slow. No meeting has yet been called. Dr. Griggs has been asked to solicit opinions of biologists individually. This is a matter which the Council should discuss and provide for general expression of opinion of members during the Cincinnati meeting.

(2) The UNESCO has now been joined by the United States. A Preparatory Commission is drawing up plans for the ultimate organization. This Commission consists of nine divisions. The Division of Natural Science is the one with which our Science will be concerned. Ultimately the President will appoint five delegates to UNESCO and a 100-member national commission to advise them. The development of organization and policies of UNESCO is likely to be slow at times and precipitate at other times. It is well that our Society designate some member, preferably a resident of Washington, to keep in touch with the Division of Biology and the Division of Foreign Relations on UNESCO matters. This is the time when suggestions from the Society as to how UNESCO can be useful to our field of science will be welcome. All matters of international cooperation are involved, such as: revival of International Unions; plans for international meetings or congresses; exchange of students and personnel, etc. Time should be taken to discuss this matter at Cincinnati, and some expression of Society action sought.

(3) The Office of Scientific Personnel of NRC is active under the direction of M. H. Trytten. Availability of Phytopathological Personnel reported to our Society by K. Starr Chester February 25, 1946, was made available to him to incorporate in a report for Biology as a whole.

(4) The NRC Committee on Genetics of Microorganisms, of which Rodenhiser, Riker, Stakman, and McKinney are members, is planning a symposium in connection with the AAAS 1947 summer meeting.

(5) A new interdivisional committee known as the Chemical-Biological Coordination Center has been organized with the objective of correlating chemical structure and biological activity by cataloguing chemical compounds in terms of their structure, physical properties, and action upon plant and animal organisms. A biologic code is being worked out with breakdown in terms of various fields including plant pathology. Members in fungicide and antibiotic research may find this a useful source of information, and any interested may direct inquiries to Dr. W. R. Kirner, Director, Chemical-Biological Coordination Center, National Research Center, Washington, D. C.

Report of the Necrology Committee. The following members died during 1946:

JOHN L. RUE	February 8
GROVER H. BURNETT	June 16
R. A. HARPER	May 12
G. A. SCOTT	February 2
F. C. STEWART	April 24

Report of the Manager of Phytopathological Classics. Report for the fiscal year beginning October 1, 1945 and ending September 30, 1946:

Classic No. 1:	On hand, October 1, 1945	6	
	Sold during year	6	$ 3.00
	On hand, September 30, 1946	0	
Classic No. 2:	On hand, October 1, 1945	208	
	Sold during year	30	15.00
	On hand, September 30, 1946	178	
Classic No. 3:	On hand, October 1, 1945	298	
	Sold during year	33	16.50
	On hand, September 30, 1946	265	
Classic No. 4:	On hand, October 1, 1945	359	
	Sold during year	31	23.25
	On hand, September 30, 1946	328	
Classic No. 5:	On hand, October 1, 1945	594	
	Sold during year	33	41.25
	On hand, September 30, 1946	561	
Classic No. 6:	On hand, October 1, 1945	681	
	Sold during year	35	26.25
	On hand, September 30, 1946	646	
Classic No. 7:	On hand, October 1, 1945	702	
	Sold during year	38	28.50
	On hand, September 30, 1946	664	
			$153.75
Value of books sent out (fiscal year 1945–1946)			$153.75
Money received on orders of previous year			5.50
			$159.25
Money received during fiscal year 1945–1946			$157.25
Due on account			2.00
			$159.25

Assets:

Cash balance on hand, October 1, 1945	$497.53
Receipts during year	157.25
	$654.78
Liabilities:	
Stationery (overprinting)	12.50
Balance on hand, September 30, 1946	$641.53
Total due on account, September 30, 1946	$ 16.75

Report of the Editor of Phytopathological Classics. The eighth number in the series PHYTOPATHOLOGICAL CLASSICS will bear the title page: Observations, Botanical and Physiological on the Potato Murrain, by M. J. Berkeley, together with selections from Berkeley's Vegetable Pathology made by the Plant Pathology Committee of the British Mycological Society.

In addition to material indicated in the title, there is to be a 3500-word biography of Berkeley written by Dr. J. Ramsbottom of the British Mycological Society.

As a token of appreciation for the efforts of our British colleagues in the preparation of this latest PHYTOPATHOLOGICAL CLASSIC it is hoped that publication can be timed to coincide with the Jubilee Year of the British Mycological Society.

Negotiations are currently under way for the publication of Number 8 with the printer, Stone Printing Company of Lansing, Michigan, the firm submitting low bid. The cost of printing will be paid out of profits from the sale of previous issues, thereby maintaining the self-sufficient basis of managing CLASSICS.

Manuscripts are being considered for the issue to follow the one on Berkeley and further suggestions are being solicited. Qualified opinion on the merits of Tozzetti's ALIMURGIA has been surveyed, and the editor is being urged to undertake the publication of the work, which Dr. J. C. Walker deems "one of the best contributions in the

period from 1750 to 1800'' and in which Count Re sees historically the first real suggestion that plant diseases are caused by specific organisms. Other proposals for number 9 include (1) a translation of Dr. M. Navaschin's paper on *Sclerotinia betulae* (a project contemplated by the late Professor H. H. Whetzel), (2) a review of Russian phytopathological research, and (3) selections from the works of Erwin F. Smith covering in particular detail the Smith-Fischer controversy.

Report of the Placement Committee. This was the busiest year on record for the Placement Committee. During 1946, 50 plant pathologists had applications filed with the Committee which were sent to prospective employers. A total of 209 individual applications were sent to 40 prospective employers who requested them.

Incomplete reports show that at least seven plant pathologists obtained positions through the efforts of the Placement Committee.

Report of the Public Relations Committee for 1946. The procedure adopted by the Committee in 1945 has been continued. During the 8-month period since the last report, sixteen ''Ideas'' for feature stories on plant pathology have been furnished editors of national magazines. Eleven of these have developed into published stories, and publication of two others is now being arranged. One story fully illustrated in color has appeared in ''Successful Farming,'' and arrangements have been completed for an all-color photographic essay of unusual type in ''Better Homes and Gardens.'' The chief problem has been to furnish enough material to meet the requests of magazine editors.

The work of the Committee has proceeded at no expense to the Society, secretarial facilities and communications having been donated.

The Committee has been aided in its duties by the independent efforts or special assistance of other members of the Society, and it takes this opportunity of thanking them and of renewing its request for additional ''Ideas'' from any Society member.

Report of the Committee on Biological Abstracts and the Union of Biological Societies. The Committee has renewed consideration of several subjects which could not be furthered during the war, and has considered several new projects. It is recommended that The American Phytopathological Society join with other biological societies in making an annual contribution to the support of Biological Abstracts.

It is further recommended that The American Phytopathological Society petition the UNESCO and the FAO, and the National Science Foundation if it be established, to designate Biological Abstracts as their official abstracting service in biology in the United States and to provide the needed financial support.

It is also recommended that a committee of the Society be appointed to investigate the needs and desirability of some type of Annual Review of Phytopathology.

Arrangements are under way to institute the publication in Section D, Abstracts of Plant Sciences, of Biological Abstracts, of abstracts of movie films and other visual aids as they become available.

Report of the Committee on Resolutions. Be it resolved that The American Phytopathological Society express its grateful appreciation to the following for their contributions to the success of the 38th annual meeting:

Stephen Diachun, T. H. King, O. T. Wilson, J. D. Moore, and Paul E. Tilford for so capably handling all local arrangements in connection with the sectional meetings.

W. D. Valleau and Stephen Diachun for arranging all papers into sections.

The University of Wisconsin, Ohio State University, and Purdue University for projection equipment.

The management of Hotel Netherland Plaza for furnishing facilities for the meeting. Special thanks are due Miss Mary Hesse, Mr. Otto Hicker, and Mr. Oscar Kline, of the hotel staff, for very splendid cooperation.

The Cincinnati papers, The Times Star, The Post, and The Enquirer, for news coverage.

The Cincinnati Convention Bureau for handling registration and assisting in the sale of banquet tickets.

Be it separately resolved that the Society express its appreciation for the invaluable services of Dr. R. M. Caldwell during his term as Treasurer and as Business Manager of PHYTOPATHOLOGY.

Respectfully submitted,
R. H. WELLMAN
R. H. LARSON

Elections and Appointments. A committee from the Council opened and counted the ballots, results of which were announced to the Society at the banquet the evening of December 30: A. J. Riker, President; R. S. Kirby, Vice-President; J. H. Jensen, Councilor-at-large.

The Council recommended and the Society approved the appointment of H. A. Rodenhiser as Editor for a three-year term through 1949; F. L. Drayton, S. M. Zeller, M. F. Kernkamp, and G. M. Armstrong as Associate Editors for three years through 1949; M. C. Richards, Treasurer, and Business Manager of PHYTOPATHOLOGY for a three-year term through 1949; L. J. Alexander, Advertising Manager of PHYTOPATHOLOGY for 1947; L. C. Knoor, Editor of PHYTOPATHOLOGICAL CLASSICS for 1947; John Neiderhauser, Business Manager of PHYTOPATHOLOGICAL CLASSICS for 1947; R. W. Goss, Representative on A.A.A.S. Council for a two-year term through 1948.

Representatives of the Society and changes in committee personnel are given in the previous pages of this report.

One hundred and forty-three applicants were elected to membership in The American Phytopathological Society.

Reports of Officers, Representatives, and Standing Committees are published on the previous pages. According to action of the Society at the Philadelphia meeting, reports of Special and Temporary Committees are not to be published in the annual report. All committee reports submitted were considered by the Council. Those recommended for approval by the Council were accepted by the Society.

The Society approved the following recommendations by the Council:

1. That the incoming Treasurer be paid his expenses from Cincinnati, Ohio, to Lafayette, Indiana, and return in order to confer with the outgoing Treasurer relative to his duties.

2. That the advertising rates in PHYTOPATHOLOGY be raised according to a schedule submitted by the new Advertising Manager.

3. That fifty copies of one selected issue of PHYTOPATHOLOGY be made available to the Advertising Manager for use in soliciting advertising.

4. That the Society expresses its interest in bringing biologists together for more effective cooperation, and recommends that J. C. Walker, its representative in the Division of Biology and Agriculture, National Research Council, represent the Society in discussions relative to an Organization of Biologists; that he be given the privilege of selecting other members to assist him.

5. That annual dues be raised to $6.00 beginning January 1, 1948.

6. That annual subscriptions to PHYTOPATHOLOGY be increased to $7.50 beginning January 1, 1948.

7. That the sections relative to life membership in both the proposed Constitution and in the Standing Rules be deleted.

8. That the Committee on Terminology (Nomenclature) of Immunology and Use of Technical Words be abolished.

9. That an over-all Committee on Fungicides be established composed of the Special Committees of the Society dealing with fungicides together with the chairman of the Subcommittee on Fungicides of the War Committee; that the above committees become subcommittees of the over-all committee; that the new committee rotate the chairmanship annually among the various subcommittee chairmen; that the new over-all fungicide committee be empowered to add to its membership and set up subcommittees as it sees fit; that S. E. A. McCallan be designated as chairman of the over-all committee for 1947.

10. That the Subcommittee on Coordination in Cereal and Vegetable Seed Treatment Research be changed to the Subcommittee on Seed Treatment; that the Subcommittee on Standardization of Fungicidal Tests be changed to the Subcommittee on Methods; that the Subcommittee on Coordination of Field Tests with New Fungicidal Dusts and Sprays be changed to the Subcommittee on Dusts and Sprays; that the Subcommittee on Fungicides of the War Committee be changed to Subcommittee on Special Problems.

11. The appointment of R. W. Goss as the Society's representative on the A.A.A.S. Council for 1947–1948.

12. That the final report of the Executive Committee of the War Committee be accepted and the Committee dissolved.

13. That both copies of the War Committee report be given permanent bindings; that one copy be deposited in the Library of Iowa State College along with the Committee report of World War I; that the second copy be filed with the Secretary.

14. That the Special Committee on Reorganization of International Cooperation be made a permanent committee to be known as the Committee on International Cooperation.

15. That the manuscript entitled "The test tube dilution technique for use with the slide germination method of evaluating protectant fungicides" be published in PHYTOPATHOLOGY, subject to the usual editing.

16. That a new Special Committee to be known as the Committee on National Security be formed.

17. That, at his request, the books of the retiring Treasurer, and Business Manager of PHYTOPATHOLOGY be audited by a certified public accountant at the Society's expense.

18. That the expense of the new Treasurer, and Business Manager of PHYTOPATHOLOGY, be paid to visit the Burlington Free Press and Science Press in order to consult with them on publication problems.

19. That the Society give $100 to Biological Abstracts.

20. That the following resolutions be adopted: (a) "The American Phytopathological Society recognizes the outstanding services rendered by Biological Abstracts in the advancement of scientific research and education and hereby expresses the hope that UNESCO, FAO, and such agencies as the proposed National Research Foundation may recognize the usefulness of Biological Abstracts, may avail themselves of its services, and may give encouragement to its work as an instrument of scientific progress"; (b) "In view of the heavy losses sustained by American agriculture from sweeping outbreaks of plant diseases, The American Phytopathological Society considers that one of the most important services needed by American farmers is a more effective reporting and forecasting service, and a vigorous program of research basic to such a service. The support of all those responsible for the administration of agricultural research is solicited toward this end"; (c) "Be it resolved that The American Phytopathological Society recommend to the 80th Congress the prompt passage of insecticide and fungicide legislation to replace the outmoded Federal Insecticide Act of 1910; be it resolved that The American Phytopathological Society go on record and advocate the passage by the several states of the Model State Insecticide-Fungicide Act where such new legislation is deemed necessary or where existing state laws are being modified to obtain uniformity"; (d) "In publication 16 of the International Crop Improvement Association, entitled 'Minimum Seed Certification Standards,' it is noted that minimum tolerances have been recommended for certain seed-borne plant diseases. This Society wishes to commend the Association for making this start, and to urge continued effort toward the improvement of these tolerances and their extension to other diseases and to other crops. The American Phytopathological Society offers its cooperation in helping this worthy cause to the end that seed-borne diseases may be brought under better control through the general use of disease-free, certified seed"; (e) "Many projects in plant pathology, entomology, genetics, biochemistry, plant physiology, ecology, and other basic sciences cannot be organized exclusively on a crop basis, nor can such projects be formulated around a single field of plant science. To adhere to the crop basis concept eliminates from consideration much of the most fundamentally important work in the plant sciences. For this reason it is respectfully suggested that when future projects of the Hope-Flannagan type are planned, provision be made for consideration of some projects on a more comprehensive science subject basis"; (f) "That an attempt be made to establish the science of Plant Pathology as a distinct science unit to be recognized as such in the biological science group; that scientists trained as plant pathologists make greater progress when allowed to operate as a group or department rather than divided into various related groups or departments."

20. That the President shall appoint alternates for Councilors-at-large who are unable to attend official meetings; that this directive be added to the new Constitution.

21. That the Proposed Constitution, prepared by the Committee on Society Organization, be adopted with the following changes: Article II, Section 1, delete Life Membership. Section 2,d Life Membership, delete. Article IV, add Section 7, The President shall appoint alternates for Councilors-at-large who are unable to attend official council meetings. Standing Rules. 1. Change (b) to read, Members whose dues are in arrears one month shall be dropped from the rolls. Members in arrears may be reinstated, without the formality of reelection, by payment of current dues. 2. (e) Line 2, change $6.00 to $7.50. Line 3, after Canada, change $6.25 to $7.75, and after other countries, change $6.50 to $8.00. Line 4, change 60 cents to 75 cents. (f) Line 1, delete the word all. 7. (c) Line 1, insert Summaries of, after Publication. (d) Delete. 8. (c) Line 1, insert summaries of, after publication of. 9. Delete.

22. That The American Phytopathological Society meet with A.A.A.S. unless The Botanical Society of America should meet elsewhere, in which case the Program Committee is empowered to make arrangements to meet with The Botanical Society of America if it considers such a meeting desirable.

REVISED CONSTITUTION OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

(Ratified at the 38th Annual Meeting of the Society, Cincinnati, Ohio, Dec. 30, 1946)

ARTICLE I—NAME AND OBJECTIVES

The name of this Society shall be The American Phytopathological Society. Its objects are to promote: (1) the increase and diffusion of all aspects of knowledge relating to plant diseases and their control, (2) effective working relations between persons professionally engaged in this field of study, and (3) coordination of various interests and services pertinent thereto.

ARTICLE II—MEMBERSHIP

Section 1. The Society shall consist of Charter Members, Annual Members, Patrons, and Sustaining Associates.

Section 2. (*a*). *Charter Members.* The Charter Members are the one hundred thirty persons who accepted the invitation of the Organization Committee of October 25, 1909, to form the Society.

(*b*). *Annual Members.* All persons interested in the study of phytopathology, including the practical control of plant diseases, shall be eligible to membership. Members may be elected at any regular meeting of the Society or by the Council in the interim. Applications for membership shall be endorsed by at least one member of the Society. Annual members shall pay such annual dues as are prescribed in the Standing Rules.

(*c*). *Patrons.* Any person making a payment to the Society of such amount as may be prescribed in the Standing Rules shall be designated a Patron and, upon election to membership, shall have all the privileges of an Annual Member.

(*d*). *Sustaining Associates.* Any firm making an annual contribution to the Society of such amount as prescribed in the Standing Rules shall be designated a Sustaining Associate, and shall receive the official journal without charge.

ARTICLE III—OFFICERS

Section 1. The officers of the Society shall be a President, a Vice President, a Secretary, and a Treasurer.

Section 2. The duties of the officers shall be those customarily pertaining to these offices.

ARTICLE IV—COUNCIL

Section 1. The government of the Society, and its corporate authority as defined in the Society's Articles of Incorporation, shall be vested in a Council which shall consist of the contemporary officers, the retiring President, and the Editor-in-Chief and the Business Manager of the journal PHYTOPATHOLOGY, a Councilor from each unit of the Society that is organized as a Division, and two Councilors-at-Large.

Section 2. The President shall call meetings of the Council at his discretion or upon the written request of three of its members. He, or in his absence, the Vice President, shall preside at meetings of the Council.

Section 3. The presence of a majority of the Council shall constitute a quorum for the transaction of business.

Section 4. All actions of the Council or officers must be authorized or approved by the Society at the annual meeting except as specified in Article VII, Section 3.

ARTICLE V—SELECTION OF OFFICERS AND COUNCILORS

Section 1. The President, Vice President, and Councilors-at-Large shall be elected by ballot. The Secretary shall send a nomination ballot for these offices to all members of the Society in time to allow nominations to be returned not less than two months before the date of the annual meeting. The Council shall designate the nominees for any office when such nominations are wanting, or are tied. The names of the three persons who receive the highest number of nominating votes for each office shall be placed on a final ballot, which shall be sent to each resident member not less than one month before the annual meeting. If the same person should receive sufficient ballots to qualify for nomination to more than one office, his name shall be placed on the final ballot as a candidate for only the higher office as listed in Article III, Section 1. These ballots shall be returned to the Secretary and shall be canvassed by the Council. A plurality vote shall elect.

Section 2. The Secretary and the Treasurer shall be appointed by the Council, ordinarily for terms of three years, which shall not expire concurrently, and the Council may adjust the term or the date of assuming office to avoid this contingency.

Section 3. The President and the Vice President shall assume office upon the final adjournment of the annual meeting at which they are elected. They shall not be eligible to immediate reelection to the same offices.

Section 4. The terms of the Councilors-at-Large shall be two years beginning with the final adjournment of the annual meeting at which they are elected, or until their successors are elected.

Section 5. Division Councilors shall be elected by their respective Divisions in such manner and for such terms as the Divisions may prescribe.

Section 6. The Council shall fill by appointment any vacancy, except that of a Division Councilor, occurring within the prescribed term, such appointment to continue for the unexpired balance.

Section 7. The President shall appoint Alternates-at-Large for the Councilors-at-Large who are unable to attend the official Council meetings.

ARTICLE VI—SOCIETY JOURNAL AND EDITORIAL BOARD

Section 1. The official publication of the Society shall be the journal PHYTOPATHOLOGY.

Section 2. The Council shall appoint an Editor-in-Chief and a Business Manager of the Journal for terms of three years not expiring concurrently, and also an Editorial Board as prescribed in the Standing Rules.

Section 3. The Council may authorize the Editor-in-Chief and the Business Manager to employ such assistants as may be necessary for the proper conduct of their work.

ARTICLE VII—COMMITTEES AND CONDUCT OF SOCIETY BUSINESS

Section 1. The Council shall appoint such standing and special committees as may be appropriate for conducting the business of the Society.

Section 2. (*a*). *Standing Committees.* Committees whose functions include the general policies and internal relations of the Society, and its relations with other organizations, shall be known as Standing Committees. They shall have a revolving membership and shall submit an annual report to the Council at the Society's annual meeting.

(*b*). *Special Committees.* - Committees whose function is to deal with special subjects of concern to the Society shall be designated Special Committees. Each special committee shall be continued for such period as in the judgment of the Council may be necessary for the accomplishment of its purpose. Interim reports may be requested and a final report shall be made to the Council at the close of this period.

(*c*). *Temporary Committees.* Committees for the accomplishment of a specific purpose, limited in scope and time, may be appointed by the President to serve during his term and to make such reports to the Council as he may direct.

Section 3. In the interim between regular meetings of the Society the Council may undertake and carry out such actions as it deems advisable or necessary, including the reference of particular questions to the Society members by mail or by notices in the official journal, subject to approval by the Society at its next meeting.

ARTICLE VIII—FUNDS

The control of funds of the Society received from dues, subscriptions to the Journal, gifts, bequests and endowments shall be vested in the Council to administer through the appropriate fiscal officers and committees. An audit of the receipts and disbursements shall be made annually by a temporary committee, or at the discretion of the Council by a certified public accountant. The reports of the Treasurer and the Business Manager, together with that of the auditing committee, shall be published annually in the official journal.

ARTICLE IX—MEETINGS

A general meeting of the Society shall be held each year, unless prevented by a national emergency, at such place and time as the Council may direct. Special or local meetings for the presentation of scientific papers or demonstrations of experimental results may be arranged at the discretion of the Council.

ARTICLE X—DIVISIONS

Section 1. Branch organizations or units within the Society, known as Divisions, may be established within the geographical area of North America, provided that a formal application setting forth the reasons for such establishment is made to, and approved by, the Society.

Section 2. The organization and the operations of Divisions shall be governed by the specifications relative to Divisions in the Standing Rules.

ARTICLE XI—AFFILIATED SOCIETIES

For the purpose of promoting international collaboration between professional organizations in the field of plant pathology, the Council of The American Phytopathological Society is authorized to establish affiliated relations with other phytopathological societies in accordance with the provisions pertaining thereto in the Standing Rules.

ARTICLE XII—RATIFICATION AND AMENDMENT

Section 1. This Constitution shall become effective upon its ratification in accordance with the procedure for amending the original Constitution of the Society. It shall supersede the original Constitution and all amendments thereto.

Section 2. This Constitution may be amended at any annual meeting of the Society provided that any proposed amendment be approved by the Council and be published in the official journal, or otherwise communicated to all resident members, at least one month before the annual meeting, and that it receive the affirmative votes of three fourths of the members voting at a regularly scheduled business session.

STANDING RULES

1. DUES, ARREARS, REINSTATEMENT

(a). The dues for all annual members as defined in Section 2(b), Article II of the Constitution, including subscription to PHYTOPATHOLOGY, shall be $6 a year, payable by February 1. The Business Manager is authorized to discontinue sending the journal to members whose dues have not been paid by this date.

(b). Members whose dues are in arrears for 1 month shall be dropped from the rolls. Members in arrears may be reinstated, without the formality of reelection, by payment of current dues.

(c). The contribution of a Patron shall be one thousand dollars, payable in one sum.

(d). The annual contribution of a Sustaining Associate shall be at least one hundred dollars, and a list of Sustaining Associates shall be published in each issue of the Journal.

(e). The payments received from Patrons and Sustaining Associates shall be credited to the current funds of the Society. These funds shall be transferable to the account of PHYTOPATHOLOGY, or may be used for other purposes authorized by the Council.

2. PHYTOPATHOLOGY

(a). *Editorial Board.* The editorial policy of the official journal, PHYTOPATHOLOGY, shall be vested in an Editorial Board consisting of an Editor-in-Chief, three Editors, and twelve Associate Editors; the business control shall be vested in a Business Manager and an Advertising (or Assistant Business) Manager.

(b). *Selection of Board Members.* This Board, aside from the Editor-in-Chief and the Business Manager, the manner of whose appointment is prescribed in Article VI, Section 2 of the Constitution, shall be selected from the membership by the Council in consultation with the Editor-in-Chief, and approved by the Society.

(c). *Terms of Office.* The term of each member of the Board shall be three years, provided that the terms of the three Editors shall not be concurrent, and that four Associate Editors shall be appointed each year. The Council is authorized to make any adjustments in these terms of office necessary to effect non-concurrence.

(d). *Compensation of Advertising Manager.* The Advertising Manager may receive compensation for his services on a commission basis as determined by the Council.

(e). *Subscriptions and back numbers.* Subscriptions to PHYTOPATHOLOGY for institutions and non-members shall be $7.50 per year in the United States and dependencies; Canada, $7.75; other countries, $8.00. The price of current single numbers shall be 75 cents. The sale and price of back volumes or numbers shall be determined by the Business Manager with the approval of the Council. Requests to supply lost copies of the journal without charge must be made within sixty days from date of issue.

(f). *Income from advertising.* Income received from the sale of advertising space in PHYTOPATHOLOGY shall be devoted to the production of the journal.

3. PROGRAM COMMITTEE

The program for the annual meeting shall be in charge of a temporary committee consisting of the President, Vice President, Secretary, Editor-in-Chief, and such addi-

tional members as the President may select. This committee shall have full authority over the scheduling of sessions and demonstrations, and the allocation of papers.

4. EXPENSES OF OFFICERS AT ANNUAL MEETING

The Secretary, the Treasurer, and the President, or in his place the Vice President, are authorized to receive reimbursement from the Society for travel expenses in connection with their attendance at the annual meetings.

5. AUDITING COMMITTEE

An auditing committee shall be appointed by the President each year which shall, prior to the annual meeting, audit the accounts of the Treasurer and the Business Manager, and certify their audit in a written report to the Society at the final business session. The Council may at its discretion authorize an audit by a certified public accountant as well as an auditing committee. Such audit shall be published in the official journal.

6. SUBMISSION OF PAPERS AND ABSTRACTS

Members who wish to present papers at the annual meeting must submit to the Secretary three copies of each abstract. These abstracts must be clear and concise, contain no tabular data, and not exceed 200 words in length. They should include only statements of fact, unpublished information, and directly derived conclusions or hypotheses. Reports of progress, or of disease occurrences, or of routine tests of ordinary control measures, are not desired, unless new and significant developments are clearly indicated.

(a). *Date due.* Abstracts must be received by the Secretary not later than 60 days prior to the annual meeting. The Secretary shall return to the author abstracts received after the closing date. Members are requested not to submit abstracts unless they expect to attend the meeting.

(b). *Number.* Each member is limited to two papers on which he may appear as sole, senior, or junior author.

(c). *Editing and Reviewing.* Abstracts are to be reviewed by a committee appointed annually by the Editor-in-Chief of PHYTOPATHOLOGY, and this committee is directed to reject or return to authors for revision such abstracts as fail to meet the stated requirements.

(d). *Time Limit on Papers.* Members are requested to limit presentation time to 5 to 10 minutes. The maximum time allowed for other than invitation papers will be 15 minutes. Complicated tables or graphs should not be shown.

(e). *Publication of Abstracts.* Abstracts of papers presented at the annual meeting shall be printed in PHYTOPATHOLOGY at the expense of the Society, provided that not more than two abstracts under the sole or joint authorship of one member, that are presented at meetings of the Society or the Divisions, shall be published at the Society's expense within one calendar year.

7. DIVISIONS

The following provisions shall govern the organization and regulation of Divisions of the Society.

(a). *Name.* Divisions shall use the name of the parent Society with appropriate geographical term; for example, The American Phytopathological Society, Pacific Division.

(b). *Membership.* Divisions shall elect to full membership only members of The American Phytopathological Society, but each Division may elect associate members under such rules as it may adopt.

(c). *Publication.* Summaries of the proceedings of the annual meetings of Divisions shall be published in PHYTOPATHOLOGY at the Society's expense. Abstracts of papers presented at Division meetings also may be published in PHYTOPATHOLOGY subject to the rules governing the preparation and publication of abstracts as stated in Rule 6, and with the specific limit of two on the number of abstracts that any member may have published at the Society's expense within one calendar year.

(d). *Constitution.* The constitution or articles of organization of all Divisions shall contain a provision or provisions ratifying the above rules. The constitution of all Divisions shall contain nothing in conflict with the constitution of The American Phytopathological Society. With the exceptions defined by the above rules, the Divisions shall enjoy complete autonomy.

8. AFFILIATED SOCIETIES

The following provisions shall govern the establishment of affiliated relations with other phytopathological societies.

(a). Upon advice to the Council that affiliation is desired, the Council may invite to affiliation with The American Phytopathological Society any other professional society in the field of plant pathology.

(b). The existence of affiliation of other societies with this Society shall be indicated by listing the names of affiliated societies in each number of PHYTOPATHOLOGY.

(c). The Council may at its discretion authorize the publication of summaries of the proceedings of annual meetings of affiliated societies in PHYTOPATHOLOGY.

(d). The Council may at its discretion authorize the publication for limited periods, subject to annual renewal of the privilege, of research papers of members of affiliated societies who are not members of The American Phytopathological Society.

9. SOCIETY REPRESENTATIVES IN OTHER ORGANIZATIONS

The Council is authorized to select, with the approval of the Society, representatives in other organizations in which the Society is entitled to representation. The following are specifically authorized: two representatives on the Council of the American Association for the Advancement of Science for a two-year term; one representative on the Division of Biology and Agriculture of the National Research Council for a three-year term; one member of the Editorial Board of the American Journal of Botany for a three-year term; and one member of the Council of the Union of American Biological Societies for a three-year term.

10. AMENDMENTS

These rules may be amended by a majority vote of the members voting at any regular meeting of the Society, or by a majority vote of the members voting in a ballot conducted by mail.